A BRIEFER GENERAL PSYCHOLOGY

By

GARDNER MURPHY

Columbia University

HARPER & BROTHERS PUBLISHERS

New York and London

A BRIEFER
GENERAL PSYCHOLOGY

Printed in the United States of America

E-W

CONTENTS

FOREWORD

EXPERIENCE in the use of *General Psychology* as a textbook has shown the desirability of making certain changes for those who wish a less detailed and lengthy presentation of the subject matter of psychology. Revision is needed especially for those who wish to avoid all technical and controversial matters, and in particular for those who are required to complete the course in psychology in one semester. The present revision of the book is about four-fifths as long as the first edition of *General Psychology.* Almost every page of the original edition has been rewritten, and some chapters are practically new. I have simplified much unduly difficult material; and many passages which discussed controversial matters without leaving the reader with a basis for a conclusion have been subordinated or eliminated Over one hundred instructors, in about eighty colleges and universities, have been good enough to aid in the revision by giving suggestions and by telling what have been the good and bad points of *General Psychology* in their own classroom experience. Though it is hoped that this book will meet the needs of many, it is not regarded as a finished job and additional criticisms and suggestions are welcome.

I have received a good many requests for a more unified statement of personal views, less eclecticism, more confident expression of an individual outlook. For what it may be worth, I venture to put down here the few doctrines or opinions which I regard as fundamental in the present text, emphasizing that despite the incompleteness of evidence I feel these principles to be in a sense the framework with reference to which all the details may be seen.

1. All development obeys a general pattern similar to that which Coghill has recently described. Not only is Coghill's presen-

tation of the principle of development from the general to the specific accepted fully in the realm of individual growth; it is accepted in relation to the growth of the race It is also accepted as a vital principle in the development of habits of perception in the individual child and in the adult as he confronts each new type of situation Even the learning process may be regarded as a gradual passage from non-specialized, diffuse or chaotic response toward localized, specialized response. Where the theoretical limits of this principle stop I do not know. The whole thing is remarkably similar to Herbert Spencer's doctrine of evolution, which seems to me to be one of the three or four great ideas put forward in the nineteenth century. I am convinced that a large part of Gestalt psychology could be more clearly stated if Spencer's developmental pattern were explicitly recognized. I believe that a large part of the problem of psychology is a problem relating to the nature of development, and that Spencer's formula is the clearest that is available to us today.

2. It seems to me that Spencer was correct in believing that progress from the general to the specific is a clue to the chief phenomena of integration. That which has not become specific cannot be integrated Nature cannot work with the diffuse and homogeneous Integration is that principle by which distinct parts emerging in the process of differentiation are thrown together into a synthesis, not a mere sum of elements, but a unified, organic pattern This is not orthodox Gestalt psychology, if the writings of Koffka and Köhler are still regarded as orthodox expressions of that psychology. I am indeed very profoundly indebted to these writers, yet I do not believe that a Gestalt psychologist can logically speak of integration of elements, because he cannot admit elements in the sense in which I use the term, and the Gestaltist cannot admit integration as a process which is carried out quite literally *by the elements themselves.* For him the whole is prior to the parts, both logically and chronologically. With Spencer—and, I believe, with Coghill too—there are two entirely different senses in which the whole may be contrasted with the parts The undifferentiated, homogeneous whole may undergo differentiation. and we then have parts. These parts.

however, may be synthesized into an organic integration or system. Obviously the term whole as applied to this new synthesis does not refer at all to the "whole" which existed at first, prior to differentiation It seems to me that students of Gestalt have emphasized the first type of whole, namely, a more or less unresolvable unit, but most unfortunately tended to forget or to slight the second type, the *system of elements.*

3. Throughout the bewildering maze of discussions of learning in contemporary psychology one doctrine seems to me to be of paramount importance and to be worthy of explicit and sustained emphasis. This is the theory of dominance, discussed at great length by the Russian physiologists, and brilliantly surveyed and interpreted by G. H. S. Razran Whenever there is a failure of perfect integration the principle of dominance—that the greater becomes greater still, the lesser tends to vanish altogether—appears to be the chief clue to what happens. Even the principle of integration itself is profoundly affected by the principle of dominance, for integration is not a passive process imposed from without. The dominant element in a pattern is in a sense the key to the integration. All the facts of learning, without exception, seem to me to illustrate the principle of dominance. There are, of course, other principles which need to be combined with the principle of dominance in order to give a complete explanation

4. The concept of the threshold, as put forward particularly by Sherrington, has seemed to me to be a major clue to the investigation of reflex action, motivation and learning. The earlier use of the concept by Herbart and Fechner has been almost completely overlooked; my neglect of these earlier uses of the term is deliberate. The concept of the threshold seems to me to be really important as a clue to understanding under what conditions functional connections are set up between different parts of the body. In this sense the threshold is obviously related to the concept of dominance. In fact, neither concept can be clearly developed without the use of the other. Dominance is, so to speak, effective because the body permits some potential acts to achieve values above the threshold while others achieve values which lie beneath it. In the course of time the dominant activity is the only one above the

threshold, and all its enemies have been reduced to impotence and oblivion.

These four concepts are not indeed the only ones over which I have labored at length and which I have constantly reintroduced in a new connection in the effort to give the reader a sense of continuity and consistent emphasis of cardinal principles. Four, however, are enough for an elementary textbook. In fact, I should have thought that they were too many, were it not for the demand of my colleagues for more interpretation amidst the details of experimental fact.

The decision to use a large number of illustrations arises from a deep-seated conviction that it is possible in college work to make serious and extensive use of "visual education." Materials which are often too difficult to present in the general course can, I think, be made intelligible if many clear illustrations are used and detailed captions supplied for the guidance of the student. In fact, the figures and the captions beneath them are often more than "illustrations" of the points made in the text; they are intended to be of interest on their own account and to be thoroughly studied as part of each assignment. In some cases, matter which might be presented as part of the text is made into a caption as a way of enabling the student to compare verbal and pictorial or graphic material back and forth, and in this way make it more vivid. In some cases, notably in the presentation of the elementary facts about the nervous system, the pictures and graphs follow in rapid succession, my conviction being that illustrations involve somewhat less wear and tear than verbal descriptions of things which students have never seen. At the same time, since the picture or graph has to be static and formal, the instructor may show in detail the relations between such over-simplified figures and the shifting dynamic patterns which they are supposed to illuminate. The instructor is also urged to make sure that all students fully understand how to read graphs, in particular that they look to see what is represented on each of the axes before studying the details of the curve.

Probably the most important suggestion the author can make

as to effective use of this book relates to the use of the glossary and index. The meaning of each new term is supposed to be clear at the time the term is first used; this term may not reappear again for fifty or one hundred pages, and when it reappears the second time, it will usually not be defined. It may be worth while to look up the *first* reference to each such term.

The cross-references which appear in the text will also help to explain some passages which would otherwise be difficult; phrases such as "see page —" or "cf. page —" are inserted only when it is thought they will be of actual help in tying together closely related topics.

The bold face headings have been so arranged that they serve as an outline for each chapter, so that they can be scanned to get a preliminary view of what one is to study.

ACKNOWLEDGMENTS

My obligations to Eli S. Marks and Eugene L. Horowitz are many and great, and must be named first

I am also most grateful to E. E. Edelman for arranging laboratory set-ups and to L V Bergman for photographing these.

Helpful suggestions for improvement of the manuscript were obtained from Gordon L Barclay, Horace B. English, Harry Helson, Rensis Likert, Georgene Hoffman Seward, and John P. Seward, Jr.

I am indebted to the Columbia University Press for permission to use or rework certain materials contributed by me in 1932 to the revised syllabus of the Home Study Course in General Psychology, Columbia University, namely, part or all of the material on the following pages of the syllabus: 70, 79, 80, 84-101, 105-108, 122-125, 140, 145-156, 163-167, 174-177, 183, 187-192, 200-207, 210-214, 220-221; also the following "test exercises". II, 7; V, 2; VI, 1, 4; VIII, 4; IX, 4, 7; X, 5-8; XI, 4; XV, 1, 3; XVIII, 1-3; XX, 1; XXIII, 1, 2; XXIV, 1-3 The earlier outline of the same syllabus, prepared in 1927 by Harold E. Jones, has also been suggestive of a number of points which I should probably have overlooked; the material on "levels of problem-solving" (pages 333-334 of this book) is directly from Jones.

To many publishers, editors, and authors, I am indebted for permission to reproduce half-tones or line cuts. Acknowledgments to source appear in connection with each illustration, but my obligations are so great as to make it incumbent on me to name here my indebtedness to the following:

Félix Alcan
D Appleton and Company
P. Blakiston's Son and Company
Cambridge University Press
Clark University Press
Wilhelm Engelmann
Lea and Febiger
J B. Lippincott Company
Longmans, Green and Co
McGraw-Hill Book Company, Inc.
The Macmillan Company
W W. Norton & Co , Inc.
W. B Saunders Company
Teachers College Bureau of Publications, Columbia University
University of California Press
University of Minnesota Press
Urban & Schwarzenberg
Warwick and York
Williams & Wilkins Company
World Book Company
Yale University Press

American Journal of Orthopsychiatry
American Journal of Psychiatry
American Journal of Psychology
British Journal of Psychology
Bulletin of the Neurological Institute of New York
Genetic Psychology Monographs
Journal of Applied Psychology
Journal of Comparative Psychology
Journal of Educational Psychology
Journal of Experimental Psychology
Journal of General Psychology
Journal of Genetic Psychology
Journal of Heredity
Journal of Social Psychology
Psychological Clinic
Psychological Monographs
Psychological Review
Scientific Monthly

G. M

Morningside Heights,
New York City,
January, 1935.

A BRIEFER
GENERAL PSYCHOLOGY

CHAPTER I

PSYCHOLOGY AS A SCIENCE

MANY fields of knowledge contribute to the understanding of human beings. The historian studies human nature, for history tells of the changing habits and ideas of nations and of the individual men and women who helped to make these changes. Economics and sociology tell of the ways in which people work, buy, sell, rear children, and regulate their own behavior by customs and laws. Biology tells how the body is made, how it works, and how it varies from one person to another. One science, however, the science of psychology, is concerned more directly with the study of human nature for its own sake. It is not content to learn the laws of behavior indirectly through studying the events of history or the structure of the body, but wishes to analyze directly the nature of man's response to the world about him. It tries to find the ways in which the world is perceived, understood, and responded to, the laws governing all our interactions with the environment and with one another.

Psychology is closely related to biology.—Though psychology is more interested in what we do than in the way in which the body is made, it is nevertheless closely related to biology. The reason is twofold: first, what we do depends in large part on how we are made; second, we are a product of the evolution of life on the earth and the biologist helps give perspective on this evolution. The modern point of view in psychology is evolutionary. Biologically, man is a recent addition to the forms of life upon earth, and his mental and physical capacities may be understood in terms of the kind of struggle for existence through which his animal ancestors have passed. Psychology finds, as we shall see, that human nature is infinitely easier to understand if the biolog-

ical background, the nature of evolutionary development, is understood.

On the other hand, psychology is also concerned with the study of the relation of man to his fellows. We just said that the modern viewpoint is evolutionary. It is also true that the modern point of view emphasizes the relations of people to one another. Men have not only evolved as living human beings; they have invented and developed an amazing thing called civilization, which powerfully influences almost everything they do A great deal of the life of a civilized man is to be understood only in the light of the customs and habits of the group to which he belongs. Psychology is therefore very close to sociology and economics, which study the life of men in communities. Psychology lies squarely between biology and these social sciences, using what they have to teach and helping them to work together in giving us a unified picture of human nature

Human nature can be understood only in the light of a knowledge of the whole organism.—Perhaps the reader has begun to wonder at this point whether we ought not to add that psychology differs from all other sciences because it studies the *mind.* This is a good question, for in everyday life we regard mind and body as two distinct things. This view, however, leads to many curious contradictions, and we shall have to ask what the term *mind* means. If you feel a pain at the end of your little finger, you are sure the pain is right there in the finger. But if a man whose arm has been amputated feels just the same kind of pain "at the end of his finger," i e., where the finger *would be* if he still had the arm, most people will say that the pain is just "in his mind." The man in the street talks as if the mind were a "place" in which you can put things. He will even tap knowingly on his skull as he looks at an insane person who suffers from hallucinations of the devil, and he will assure you that the devil which the insane person sees is "in his mind." Now actually if you open the poor lunatic's skull, you will not see a devil, but a brain. What and where is this "mind" that we talk about daily? *It is not a place at all, nor is it a thing.* It is essentially a name for certain *activities* of persons,

activities such as remembering, thinking, imagining, etc. For this reason we have a serious quarrel with the popular notion that the mind and the body are two distinct and separate things, each existing in its own realm. Modern psychology, with its biological point of view, must regard mind as a name for certain activities of living beings. It does not believe there is such a thing as an independent "science of the mind" considered apart from the living being as a whole. For that reason we cannot accept a definition of psychology in terms of mind alone, but must speak of the *whole living being*, to which we give the name "organism" This organism is in touch with its environment, both its physical environment and its social environment.

For everything which we do there is some definite cause, and it is the business of the psychologist to find out what kinds of causes may lead to each kind of behavior. The causes which produce responses are called *stimuli.* For the most part these stimuli are outside of the body. In fact, in many psychological problems the main task of explaining behavior consists in tracing the relation of stimuli outside of the body to responses which are made by the muscles. Sometimes, however, the understanding of the responses demands not only a study of the outside stimulus but the discovery and analysis of other stimuli which are inside the body itself. These stimuli inside the body are sometimes easy to trace, as when hunger is found to depend upon contractions of the stomach, but in some cases internal stimuli are quite complicated. The sleepy man's ability to keep his mind on the balancing of his bank account may depend largely on his posture and on the way he says the numbers to himself. Relaxation of his muscles would make it difficult to keep the task in mind What seems to be an entirely immaterial thing, namely, a thought, is found to depend upon what is going on in certain muscles. The mind and body must therefore, in so far as we study them scientifically, be considered as aspects of one indivisible whole.

Terms like memory, thinking, feeling, or perceiving, describe whole activities of the organism. If we say in a later chapter that we "perceive" a low tone having a given pitch, we shall be refer-

ring not to an isolated mental event, but to a response which depends upon the ear, the nerves to the brain, the brain itself, and the various muscles which adjust themselves as the sound is heard, as well as to the experience of hearing the tone. It is convenient at times to separate parts of the organism from the rest of it for purposes of description; for example, to tell what the finger muscles do without taking account of the muscles of the forearm. In the same way it will be convenient to describe certain complicated activities called thought and imagination without taking account of other activities going on simultaneously. This procedure is justified only if the true unity of these separate activities can be kept in mind by the student. We shall in fact make our own effort to point out this unity at many points in the book, for example, in Chapters X and XXIII.

Why does popular usage separate body and mind? The answer lies in the habits of our remote ancestors The savage tends to think that within his body there is something which behaves in ways unlike most things which he can observe outside him. For example, he dreams of a long journey, participates in a distant battle, and upon waking is assured by his companions that his body has lain in sleep since the previous evening In such a dream he may not only wander far afield, but talk with those who have long been dead. To him this is clear evidence that a mind or soul, an intangible and invisible thing, can wander forth and converse with other minds which have lost their bodies. Even when he is awake the soul seems to go away sometimes. If he shuts his eyes he can in some cases imagine himself at a distance; sometimes his imagination is so vivid that he forgets where he really is. The savage finds this sufficient evidence that mind is an immaterial, intangible thing, traveling great distances which the body cannot travel, and possessing certain powers which no body possesses. These notions of primitive man have come down to us by tradition century after century, and although our notions are less crude we still use words suggesting that the mind is a sort of separate thing or a place in which to put intangible things like thoughts and ideas.

We derive psychological information chiefly from experiment.—In other sciences problems are frequently suggested by everyday life and are then taken into the laboratory for more careful study. In many cases everyday observations are confirmed and amplified by experiment. In other cases everyday observation turns out to be inaccurate, and what we have called "common-sense" assertions turn out not to be true at all. In chemistry, for example, most of the true elements failed to be observed under ordinary life conditions, and most of the things which the novice considers as chemical elements, like "water" and "air," have been found by the chemist to be compounds or mixtures. The world of nature has always proved too complex for scientific study without the use of instruments, particularly instruments for measurement. When the object can be taken into the laboratory, subjected to various temperatures, pressures, and so on, its true properties are discovered. Psychology is much like chemistry in this respect. It takes the observations of everyday life into the laboratory, and tests them under different conditions, systematically varying one stimulus after another until it can state clearly the various factors and the relative importance of each in producing a complex result. On the basis of this sort of analysis, it may then turn over the data to the physician, the teacher, or the general public, often with a great improvement in the handling of people.

It is sometimes said that laboratory knowledge is too artificial to be important. Indeed, we are often told that a human being in a psychological laboratory does not behave like a human being in everyday life This is, of course, true. But this remark really goes to show why experiments are as necessary in psychology as in physics. If a falling body behaved all the time just as it behaves in the special conditions of a vacuum tube, we should not bother with all the expense and labor involved in studying gravity by means of vacuum tubes. It is just because the laboratory method is "artificial," permitting us to study *one factor at a time*, that we are able to make a study of all apparent causes, measuring each so carefully as to know their *combined effect* in any given situation.

Experimental psychology in the same way explores various aspects of behavior and formulates general principles. To apply this knowledge to a concrete case, it is necessary to know the principles and how to put them together, exactly as in any other science.

How did experimental methods in psychology come into existence? From 1825 to 1875, men who were studying physiology by experimental methods constantly encountered problems for which physiology did not seem a completely satisfactory solution. As they studied the eye, the ear, the muscles, and the brain, they found that these organs could be understood only by understanding the man as a whole. In order to understand how we see, they had to understand more than the functions of the eye as an optical instrument. They had to understand something of the process of perceiving the world about us. As they studied muscular contractions, they found that they had to understand individual differences in the way different persons contract their muscles, depending upon individual differences in personality. This led the physiologists to a gradual recognition that there was a need for an experimental science of psychology. Some of the physiologists became psychologists, and some psychologists who had previously been ignorant of the experimental method began to catch the viewpoint of the physiologists and to carry it over into their own field. During the years 1875 to 1900 students of the mind began to experiment actively on mental processes and on the relation of mental and physical processes. They founded and systematized experimental psychology. They have not as yet systematized the entire field of psychology; furthermore, there are many important problems which have as yet yielded very little to the experimental method. In general, however, psychologists themselves have been surprised to discover how many of their problems could be put in such a way as to be studied by experiment. Only a few years after a noted psychologist had declared that experimentation could be applied only to simple things like seeing, hearing, and feeling, and could never be applied to the higher mental phenomena, another psychologist devised and carried out a precise and brilliant study of memory. A few years later even the thought processes were

studied experimentally, and one of the great developments in recent years has been the experimental study of character. Psychologists are inclined to be impatient when they hear the prediction that science will never find a way to study this or that aspect of human nature. They admit that their ingenuity is limited and that one man's lifetime may not witness any spectacular progress in relation to some of these difficult questions, but they have faith in free and careful investigation, especially when carried out under the special conditions of the laboratory with safeguards against prejudice and overconfident theory, and with precise methods of measuring the many factors which help to determine what a person will do.

In general, the psychology described here is experimental psychology. In relation to some problems, everyday observation gives us many good starting points Sometimes careful studies in laboratories seem to contradict the conclusions based on daily happenings. This is true of other sciences besides psychology A year or two of physics and chemistry shows the student that much about which he is very sure in his everyday view of things is not true under the careful conditions of observation which hold good in the laboratory. In psychology the relative importance of everyday observation and of laboratory research, when both kinds of evidence are available, will be just about the same as in physics or chemistry. The rule is simply this: Whenever we have experimental evidence obtained under scientific conditions, we shall have to prefer it to the crude observations of everyday life which are subject to many distortions and errors

Psychology makes use of observation of others, and also observation of one's own experiences.—There are two aspects of a man's response to his environment: one aspect which is external and observable by the psychologist who watches the man; and another aspect which is a matter of the man's personal experience. The latter aspect will be better understood if the man tells us about it. If he is afraid, we may be able to study his trembling, turning pale, etc., but we may not know what he is afraid of, or why, unless he tells us. What is told us through

words is of great help. Of course, the particular words which he uses are not in themselves important for their own sake. They help us to grasp the whole situation, since we know what fear is and what some of the things are which frighten people. When we speak of psychology as concerned with responses to the environment, we mean to include and to emphasize not only the gross responses which are observable by another person, such as trembling and turning pale, but the inner responses like a sinking sensation in the stomach, or the apprehension which the man feels. Psychology is concerned with both external and internal responses.

Behaviorism would confine psychology to the study of behavior.—Our last point requires careful analysis, for it is controversial. Some psychologists deny that psychology should study experiences for their own sake The reason for their view is this: In science it is important to get accurate data. Psychology is hard to study accurately whenever it is hard for us to report exactly what has been going on in our minds. Not only do we forget; we may even deceive ourselves. People differ not only in what they say they dream about, but even as to the *main characteristics* of dreams; some say that dreams always have some orderly plan, others say they are utterly chaotic. They differ not only in what they think about, but as to the *very nature* of the thought processes. If testimony differs in this way, how can we scientifically study the mind? Some psychologists have decided, in view of this difficulty, to throw overboard the study of inner experiences altogether and to concentrate upon the study of what people do, the way in which they respond to situations around them. They have therefore defined psychology as the science of behavior. They point out that the newborn infant can be studied scientifically, that the stages by which he learns to grasp what he sees and to handle problems which confront him can all be studied in terms of *direct observation*, similar to the terms used by biologists when they speak of the behavior of animals For example, in understanding why birds fly south in the fall or north in the spring, there would be great difficulty in working out what goes on in their "minds"; biologists insist that the more fruitful approach lies in stating the

ways in which the body varies in its functions at different times of the year. Psychology modeled upon biology would study the human animal objectively, would describe the stages of his development, the way in which he learns, the manner of acquiring speech and manual skill, and would abandon altogether the attempts to discuss the mind. This type of psychology which is concerned only with behavior is called *behaviorism.*

The appeal of behaviorism will depend upon the problem which we are studying. Suppose we are attending a symphony concert and, while listening intently, single out one of the violinists and watch closely what he does. In a rapid passage he plays at a frantic pace. He seems to be reading the musical score, yet responding to the conductor as well. How does this man succeed in carrying out such a complicated task? A behaviorist might very well study such a question as this. It is a problem in behavior psychology. We have asked no questions about the mind or the consciousness of the violinist. We do not know what is going on in his mind. We ask only how he is able to play so well But suppose for a moment we are interested in the audience or, indeed, in ourselves as typical parts of the audience. We close our eyes to enjoy a musical passage which we believe the orchestra will render skillfully. We follow the music and are refreshed by its beauty. This, now, is a musical experience. It is something of importance to us, and it occurs to us that we should like to study it psychologically. The behaviorist will tell us that, in order to study our musical experiences, it will be necessary for us to describe them to him. He will then make an objective record of our words, and then study these words in an objective, scientific way. We reply that words might convey some of the experience but certainly not all of it, and that if he has had no such musical experience, the chances are very small that he will be able to make much sense out of what we say. He then proposes to apply delicate instruments to the various muscles which have been responding as we listened to the music. We agree to all this, and let him record the way we hum or beat time to the music, our tendency to breathe deeply at one point or to hold our breath at another. If we ask to look at his instrumental

records, we shall find that he has indeed caught some significant aspects of behavior which coincided with our appreciation of the music, but that he cannot discover by these methods even as much as could be discovered by the study of our words.

We need both behavior study and study of our own experiences.—We shall let the behaviorist study our words, and the words of all those who enjoy music. We shall let him use his instruments and do the best he can to find consistent laws to describe the way in which people respond verbally to music, but we shall in the meantime go on struggling for better and better ways of describing what we experience, believing that it is not the use of words, but what the words mean, that chiefly concerns us. We have no objection to the study of words, but, unless we abandon interest in musical experience, we shall regard all methods of studying words for their own sake as but poor substitutes.

Psychology studies every response in the light of the whole organism and the whole environment.—Despite what has been said, psychology owes behaviorism a great deal for its emphasis on the *unity of the organism.* Since the rise of behaviorism, psychologists are less likely to make the mistake of making "mind" and "body" two sharply contrasted things. We are eager to agree that past *behavior* may partly determine our present experiences, and past experiences must be studied to get perspective on present behavior; no psychological event can be considered except in the light of *both* sets of facts.

No mental process and no cause of behavior can be studied apart from their context in the life of the individual. A man responds not only by virtue of the way in which he is made, but by virtue of the whole life history of habits and experiences which differentiate him from every other person. In many cases, the things which physical science studies, such as a dynamo, may be studied without much reference to the whole history of the thing since it came into being. But in psychology it is necessary to understand how each individual reflects the environment to which he has been exposed, the mental and physical habits which he has picked up in family, school, club, or workshop. This means that

in looking upon psychology as a science of the organism, we must be exceedingly clear as to what an organism is. No organism, animal or man, can be fully understood without a knowledge of its past, and of the whole situation acting upon it. What will occur at any given moment, for example, in response to a very loud noise or a flash of lightning, will depend partly upon the past activities of the organism and partly upon other elements in the environment. The whole environment and the whole organism are interacting. The child who is frightened by a loud noise while alone in a strange place may be almost completely indifferent to it while at home in his mother's arms.

All these considerations suggest a definition of psychology as *the science which treats of the interrelations between the environment and the responses of the organism.* The environment brings about responses in the organism. These responses change the stimulus situation so that the organism is stimulated later in a new way, etc. The subject matter of psychology is neither the world nor the organism in isolation, but the interaction of the two. Such a definition has room for those interactions which some other organism might observe, as when one sees a friend frowning at the contents of a letter, as well as for those interactions which only one organism is aware of, as when the reader alone in his study reads this book.

The fields of psychology include: general adult normal; child; abnormal; comparative; social; applied; educational.—In a certain sense all behavior follows basic laws which hold for the normal and abnormal, for the child and the adult, even for the lowest animal and the most civilized adult man. Concretely, however, the laws which are most important in one type of behavior study are relatively unimportant in another, and some of the laws relating to the behavior of the normal adult man cannot apply to the child, the abnormal, or the animal. For this reason different fields of psychology are now recognized. Child psychology studies the development of the individual, the behavior of the newborn, and the way in which growth and learning affect the behavior patterns until the adult type of response appears.

Abnormal psychology studies mentally disturbed or mentally defective people and compares their responses with those of normal persons. Comparative psychology studies the emotional life, learning ability, and intelligence of animals from the simplest to the most complex, finding what general principles hold for all animals and how these principles apply in the case of human beings. It also makes a systematic comparison of certain specific things, such as motives, from very low to quite complicated organisms It is very close indeed to general biology. Social psychology studies human beings in their interactions with one another and takes its place alongside sociology and economics as a social science. Applied psychology considers all the materials of psychology which are useful in practical affairs, particularly business and industry. Educational psychology is really the application of psychology to teaching and learning, and can therefore be regarded as a phase of applied psychology, but it has in fact broken off completely and makes up a field of its own. Other subdivisions are vocational psychology and the psychology of personality. The present volume will draw illustrations from all of these special fields and will, it is hoped, serve as a basis for all of them. It is not, however, primarily concerned with the subject matter of any of the specialized fields. It aims to give a view of psychology as a whole, and draws most of its material from the normal adult human being. In general, the opening chapters emphasize those aspects of human psychology which lie nearest to the biological sciences, while toward the end the relation to the social sciences is emphasized.

SUMMARY

Psychology is the science which studies the interactions between living organisms and their environment. Human psychology is a branch of general psychology, and it considers man as an organism who can best be understood in the light of his biological and social evolution. It does not separate body from mind but regards mind as the name for certain activities of organisms. Psychology

stands in close relation to the biological sciences and draws freely upon them. It is also closely related to the social sciences. The psychologist studies the behavior of organisms, but he is also interested in mental activities or experiences. ~~His chief method is~~ the experimental method. In addition to normal human adult psychology, he studies child psychology, animal psychology, abnormal psychology and many other special fields. The present volume is devoted chiefly to the general laws of psychology as they appear in the normal human adult.

REFERENCES

Dashiell, J. F., *Fundamentals of Objective Psychology,* 1928, Chapter I.

James, W., *Psychology: Briefer Course,* 1891, Chapter I.

McDougall, W., *Outline of Psychology,* 1923, Chapter I.

Titchener, E. B., *A Beginner's Psychology,* 1920, Chapter I.

Warren, H. C., and Carmichael, L., *Elements of Human Psychology* (revised), 1930, Chapter I.

Watson, J. B., *Psychology from the Standpoint of a Behaviorist* (3rd ed.), 1929, Chapter I.

Woodworth, R. S., *Psychology* (3rd ed.), 1934, Chapter I.

PROBLEMS

The problems following each chapter are planned for the following purposes: to serve as a useful review and application of the material in the chapters themselves; to help the student to get perspective on the world of psychological thinking and analysis by stimulating him to formulate and analyze problems which are essentially psychological, whether these have as yet received adequate attention from experimental psychologists or not; to introduce him to the field of psychological literature of the present and to help him to acquire skill in reading and evaluating this literature. It is assumed that it is important for the student not only to acquire a grasp of basic facts and principles which the best research is able to substantiate, but also to be oriented in the resources of psychology as a science, so that he will have some equipment for independent study if he wishes to pursue further questions on his own initiative.

1. What kinds of facts is psychology primarily interested to explain?
2. What are the main methods it uses to verify its hypotheses regarding those facts?

3. Make a list of all the sciences with which you are acquainted, showing their interrelations from your own point of view
4. List the most important ways in which you think a knowledge of psychology might be useful to you
5. A psychological question is one which bears on some characteristically psychological problem, rather than on an ethical problem, it is a question of "is," not of "ought to be." Formulate a psychological question, or a series of questions, concerning each of the following

(a) typewriting	(c) motion pictures	(e) propaganda
(b) genius	(d) competition	(f) embarrassment

6. What is the difference between a "pure" and an "applied" science? Give illustrations of each.

CHAPTER II

THE RACIAL ORIGIN OF BEHAVIOR PATTERNS

MOST of the things that animals and human beings do are dependent on motives. Motives, or trends toward particular kinds of action, are properties of living matter itself. It is true that every activity of a living organism is a response to a stimulus, and that many of the stimuli act upon the body from outside; but a great many of the stimuli are activities within the body itself. An animal awakening from a long sleep may be hungry or thirsty and may begin a series of restless activities which are primarily a result of its internal physical condition rather than of changes in the environment outside These internal stimuli are the physical basis for motives. Every interaction between the environment and the organism must be seen in terms both of response to the world and of response to changes going on within the body. In a few cases conduct can be predicted from a mere knowledge of external stimuli; for example, the thrusting of a needle into the hand will cause a reflex jerk It would be appropriate enough to speak of this as unmotivated behavior There are, however, relatively few responses which can be predicted merely from a knowledge of the world outside. Simply because animals and men have many *needs*, they tend to be active and to make contact with the world outside them, as if goaded and driven by changes going on within their bodies. The process by which *needs* give rise to *behavior* we shall call *motivation*. Motivation, instead of being a special problem, a rather interesting hobby for those who wish to leave the main highroad of psychology, is a central problem in relation to which others must be seen. For example, the process of learning or associating or thinking or dreaming or perceiving may for certain purposes be studied without regard to motives. But all these proc-

esses are really aspects of the life of a whole organism which is actively doing something. When such processes as learning and perceiving are treated apart from motivation, they tend to resemble abstractions, and bear about as much relation to the actual tasks of learning and perceiving as the mathematical equations for a drowning animal's movements would bear to the animal's actual struggle. As we start the study of psychology, we shall therefore inquire first of all regarding motives, the mainsprings of action; this will serve as introduction to all that follows. Through Chapter VI we shall be concerned with the development of motives and the way in which they work, and from Chapter VII onwards we shall be concerned with the way in which perceiving, learning, thinking, etc , appear in a motivated organism

Motives and the ways of satisfying them can be understood in the light of evolution.—Understanding of motives and the ways in which they control behavior has been enriched by everything we have learned about the evolution of man and the laws of development of the individual human being. To lay a sound foundation for our later questions, it will be worth while to ask how the human being develops. We shall therefore turn first of all to consider the problem of development; in this chapter the development of the race, in the next that of the individual.

Motives are classified in terms of the kinds of need which the organism has. The motive which is at work, for example, when we struggle to get enough air is basically the demand of the body for more oxygen, while the hunger motive may be regarded as the demand of the body for more fuel. Certain motives, such as these two motives of air-getting and food-getting, run throughout the animal kingdom. All members of the animal kingdom have some form of respiration and some form of food-getting. As animals get to be more complicated in the process of evolution, they develop other motives. Birds, for example, are motivated to build nests Nests do not help in getting air, water, or food, but birds which have never had any experience with nest building nevertheless put twigs together and make a fairly good nest. Nesting is the expression of a need; the interference with this activity greatly

disturbs most birds. The process of evolution has in this and in other cases added genuine and important motives. Very roughly, the more complicated organisms will have more complicated and more numerous motives. The study of adaptation to the environment will therefore serve to show partly how the basic motives like food-getting and water-getting and air-getting must be kept alive no matter what changes the species undergoes, and will also show the need for developing new motives which will function in a more complicated type of life to which a more complicated creature must make its adjustment.

Moreover, the *methods by which motives are satisfied* become more complicated in the process of evolution. An amœba can get air without making respiratory movements and it can get food by very simple movements which result in its inclosing food particles within its body; it does not need mouth, throat or stomach. As organisms become more complicated, however, the organs which are depended upon to satisfy the motives become more complicated. These organs must also be coordinated. The nervous system, including the brain, is the chief coordination center. It is therefore natural that the nervous system should become more complicated as the needs and the ways of satisfying them become more complicated. New developments in the structure of the nervous system help give the basis for new ways of satisfying motives. The evolution of the nervous system is therefore of importance to psychology.

A few stages in the development of forms of life along those lines which led to man may be given to add concreteness to the picture. Life arose in the sea. Living matter which was not organized into cells probably existed for ages before the present types of plant and animal cells came into existence. And these cells in turn must have existed for ages before anything appeared which was hard enough to leave a residue after its death. From one-celled creatures arose many-celled creatures. From among these evolved the *vertebrates*, which had a nervous system stretching from head to tail and protected by a bony covering. From the first vertebrates

evolved fishes; from these, amphibia (animals capable of breathing in air as well as in water); and from these, reptiles—land-dwelling and air-breathing creatures adapted to the surface of the earth which was now becoming habitable on a large scale. The migration from the sea to the land, which made respiration a different sort of task and made necessary a capacity to adjust to great variations in temperature, led to the development of warm-blooded creatures, birds and mammals—each showing clear indications of reptile ancestry. The mammals gradually diverged more and more from the common stock, adapting themselves to a wide variety of life conditions on different parts of the earth's surface Groups which survived in one place made a failure of it in another. Along with the struggle between individuals of the same species went on the struggle between similar species contending for the same food supply. Those in each generation which were relatively well equipped for the struggle of life tended to survive and to leave descendants behind them. Those in each generation which were a little less successful failed to adapt themselves to the situation and fell by the wayside. If we remember the vast variety of different conditions of soil, food, weather, climate, etc., which are to be found between the Arctic Circle and the islands of the South Seas, it is not surprising that the mammalian stock produced a vast number of different forms of life

Evolution has given us more complex brains.—The nervous system, being the basis for learning and intelligence, was one of the most important of all assets in the struggle for life. In many cases animals which were not very effectively protected against their enemies, or which had no dependable means of aggression against others, were at an advantage if they could *learn* quickly and thus adapt themselves to situations which varied from those of their everyday routine. Among the many relatively intelligent groups within the mammalian stock the apes developed by far the most elaborate nervous systems. From these apes there developed at different times the four existing kinds of anthropoid or "man-like" apes.

Man is not a descendant of any existing monkey or ape. He is

related to this large group, called the "primates." The problem of "missing links" between anthropoid apes and man is now obsolete, since a large number of missing links, species intermediate in various respects between man and the apes, have been identified through discovery of their skeletons It is possible to arrange a graded series of skulls from those which have capacities about equal to the capacity of the chimpanzee, to those having the capacity of the modern man.

All living organisms have a great deal in common.—Merely because different creatures have different paws, claws, wings, bills, feathers, hair, scales, etc., we are apt to forget the fundamental similarities existing between all living things. From the amœba to the robin, from the chipmunk to the polar bear, there is a striking uniformity in the fundamental life needs and fundamental life processes which they share. The bodily tissues of a living creature are busy growing, repairing, reproducing; and the more refined the methods of biological research the more clear the chemical and physical similarity of these processes wherever they are found. In a certain sense the fundamental properties of living matter dominate human behavior as truly as they dominate the behavior of one-celled animals like the amœba.

Jennings tells what happened after he cut an amœba in two with the sharp edge of the end of a glass rod. The smaller portion fled, but was chased by another amœba that happened to be near. Flight and pursuit continued until the tiny one was swallowed and apparently undergoing digestion by the big one; then suddenly the victim worked its way free and made off, to be pursued a second time. It is not fanciful to suggest that as far as actual behavior is concerned, pursuit, flight, and even fighting and self-defense, occur at a very low level of animal organization Even without conscious purpose the pitcher plant sets a trap for its victim and devours it, much as a spider—or a human trapper—might do. In all forms of life there are not only certain needs, but certain definite similarities in the means by which these needs are fulfilled.

In the higher forms of life, however, these simple and obvious

needs are mixed with needs which seem in many ways less important in maintaining life. A chimpanzee scarcely *needs* to dance, to shout, to beat a drum, to grasp the hand of his companion and to adorn himself with odd fragments of ribbon. Many of these things may have a value by way of calling attention, or may be used in courtship, or may help directly or indirectly in the carrying out of other activities; but the curiosity, the play, the love of communication and many other forms of behavior are very hard to trace to any simple physical need. In general, it is difficult in the higher forms to find a direct relation between the needs and the functions which have developed in the satisfaction of those needs The gratitude and jealousy, despondency and triumph of these animals show a certain richness and variety of emotion which make the emotional equipment seem more like a luxury than a necessity. Even if a chimpanzee were born with the same basic needs as a tiger or a mole, the very fact of *greater ability to learn* would probably make the emotions of the animal more complex and more subtle.

We differ from other higher animals in (a) greater capacity to learn, (b) capacity to use words.—In the same way a great deal in human nature which is quite fundamental for understanding of our social behavior depends upon the richness and complexity of what we are able to learn Even without language, man's emotional responses would probably be far more varied, more subtle than those of any other animal. The differences between man and the apes are as important as the similarities. Chimpanzee society, as African explorers describe it, involves so much that is "almost human" that it is very easy to overdo the similarities To treat the ape as an "almost-man" has led to much misunderstanding, and to treat the man as an almost-ape is equally misleading. A chimpanzee, for example, lives mostly in the *immediate present.* It seems never to make an effort at conscious recall of the remote past or anticipation of the distant future. A group of chimpanzees profoundly sympathetic to one of their number who fell ill promptly forgot about him as soon as he was removed to another cage. Differences in the ability to imagine

what is remote in time or place are important in themselves, and become even more important when they are connected with a method of communication from one individual to another. One of us can remind another of something which happened long ago or something which will happen later, and we can plan together in relation to a distant situation which has at present no existence whatever. All this is dependent upon social evolution, a development of communication and of social institutions which may change human life from century to century even when the physical make-up of the brain remains practically unchanged, i.e., even at times when no *biological* evolution is going on.

Man's social evolution is just as interesting and important as his biological evolution, but he had to achieve a high level of biological development before he was capable of rapid social evolution. This biological development is largely a question of the development of his brain, with the consequent ability to learn.

The development of the brain has made possible the development of language. Though the apes can solve complicated puzzles involving the coordination of their hands, they cannot be taught speech. They have emotional cries which occur in different situations, and they learn in what situations a particular kind of cry is apt to come from one of their fellows; but they do not use words to designate objects or actions, and though many experimenters have attempted to teach them to talk, these efforts have met with very little success It is curious that an ape which can solve puzzles which baffle a three-year-old child cannot acquire the normal vocabulary of a child eighteen months old even when given prolonged and intensive training.

Recently the Kelloggs reared a baby chimpanzee for nearly a year. It was seven months old when they "adopted" it and until it was sixteen months old it was the constant companion and playmate of their own little boy. They carefully watched its development, taught it to eat and care for itself as a child is taught, praised it and disciplined it in a human way and treated it as most people would treat a child. On the basis of their study and the various mental tests which they gave the little chimpanzee at the

same time that they gave similar tests to their own child, they concluded that the little ape was very similar in behavior to the little child. A great deal of the "brutishness" which we attribute to apes did not appear at all, evidently it must depend on "brutish" surroundings as they grow up Perhaps human infants brought up among the animals—like Tarzan—would emerge as rather brutish creatures. In fact, two recent studies of so-called "wolf children" in India—children brought up by wolves for a number of years—suggest that this is so

It has taken ages upon ages to develop civilization The little infant and the little chimpanzee *as individuals* are not as completely unlike as one might think Social traditions, i e, habits handed on from one generation to the next, play an important part in determining the characteristics of all the higher animals. Tradition or civilization, then, would shape the "personality" of the animal as it does that of the man *We are speaking here only of the very early stages in individual development.* The human brain grows very rapidly for the first few years, and very much faster than that of an ape. A chimpanzee would not be able to keep up with a human infant very long, even if it were given every possible advantage Nevertheless, the Kelloggs' experiment shows the importance of social training If a "cave man's" baby of thirty thousand years ago were brought up with us, he would be a normal American, for the cave man's brain was as good as ours. What the cave man lacked was the benefit of our slowly accumulating civilization.

Evolution has provided a large number of useful ways of behaving which serve to adapt animals to their environment. The specific acts which can be depended upon by nature to aid in the struggle for existence consist mostly of muscular contractions which are called out by specific stimuli acting upon the body. When a specific stimulus calls out, by means of connections in the nervous system, a fixed and predictable muscular response, we call the response a reflex; the *whole circuit from stimulation to response* is called *a reflex arc.* Examples of reflexes are: the con-

traction of the pupil of the eye in response to light; the swallowing, sneezing, coughing movements connected with clearing the respiratory tract, and the "protective movements" like the jerking back of a hand or foot in response to a quick movement or a blow. These reflexes are to a large degree fixed and uniform for members of a species Nature has provided these through the long process of evolution, improving them step by step, eliminating those animals which could not react quickly and surely in the presence of such important things as food, light, and hard blows. If, for example, breathing were not insured by highly efficient mechanisms, animals would stop breathing in their sleep or would fail to struggle when suffocated or plunged into water. Reflexes of this sort appear even in the lowest grade of feeble-minded individual, and are usually preserved even in the profoundest mental diseases.

When we begin to think of organisms in terms of this sort of adaptation to environment, we naturally ask how man has been able to work out an adjustment, although decidedly less well adapted to his physical environment than most animals are His reflexes are certainly no better than those of many lower forms, and on the whole they seem to be less uniform and predictable than those of animals with brains less developed. We find that the invention of tools and of language, the domestication of animals, and the cultivation of the practical arts have given him, in addition to his reflexes, an *indirect* contact with his environment which has replaced many of the older *direct* contacts; his tools and inventions are a buffer between him and the environment. Instead of simply taking food as it comes, reacting to its sight, smell and touch when it appears before him, he reaps many months after he sows, and he waters and cares for the animals which in some other year will give him wool or leather with which to defend himself against the elements. As we shall see, his set of inherited reflex acts is still there, as we should expect, but the reflexes have been redirected and brought into relation to very complex needs and forms of adaptation Man's capacity to learn, which is itself a product of evolution, has added to his reflex make-up a great

variety of more complicated adjustments, and these adjustments, no matter how complicated they may be, are still adaptations to environment.

There is, nevertheless, scientific danger in defining all these functions as perfect adaptations. If one makes a catalogue of man's successes and failures in dealing with his environment, one must note that for almost every positive achievement there is some corresponding loss of adaptation. Modern medicine enables many to adapt themselves who would otherwise fail, but of course helps to preserve the unfit so that biological unfitness has a chance to perpetuate itself. War eliminates many of the most fit. In the process of prolonged trying to be civilized, man taxes his sense organs and muscles, and perhaps most of all his nervous system, imposing upon them tasks very different from those for which they are best adapted.

But the question of adaptation may be pressed still further. Many of the reflex acts which were so advantageous under simple conditions may completely fail to guarantee a good adaptation under more complicated conditions of life. The paroxysm which closes off the esophagus when the physician attempts to examine it may actually interfere with a medical examination necessary to save life. Many of the responses which we make to noises or bright light are entirely intelligible in terms of our hereditary equipment if one understands our evolution Yet the fact that these responses occur in us makes us nervous or jumpy, or they make us do exactly the wrong thing in an emergency or in other complicated conditions of modern life A great many of the emotional responses which would be serviceable under more primitive conditions are touched off so frequently in modern life—so many things, for example, get on our nerves or make us lose our tempers—that it is questionable whether we may be said to be well adapted as a whole to the civilization which we have constructed.

Our purpose here has been to question the soundness of thinking of inborn tendencies as effective adaptations, perfectly suited to the individual's needs. In the long run, our reflexes and emotional responses are such as to protect us from danger But the degree of adaptive excellence of any function will depend on the

complexity of the social situation which we try to face. Just as the stomach has changed too slowly to keep up with our rapidly changing diet, so the emotional equipment has changed too slowly to keep up with a civilization which emphasizes restraint, self-control and reasonableness. The virtues of Shakespeare's impulsive hero Hotspur are of very doubtful value in a civilization which has such different standards as ours. So, too, the practical-minded little hunchback who is presented as a "villain" in Homer's *Iliad* because he wanted to call off the war against Troy, possessed qualities amazingly like those of Steinmetz, our own great engineer. Not only were both physically deformed and creatures of brain rather than brawn; the same cold common sense, the same outspoken telling of the naked truth and scorn of "heroics" which made Homer's little hunchback a "villain" made Steinmetz an honored leader among modern engineers.

So much for evolution as a whole. We need now to consider the *process* by which human behavior tendencies have arisen

Social habits are not inherited but are learned by each generation from its social environment.—The cells of which the body is made may be classed as *body cells* and *germ cells.* The former are simply the property of the individual; their characteristics come to an end at death. The latter, the germ cells—eggs and sperms—have the capacity to produce new individuals. They are hidden within the body and well protected, so that the accidents and injuries which affect the body cells have, for the most part, no effect upon them. The true stream of heredity from one generation to the next is suggested in the figure.

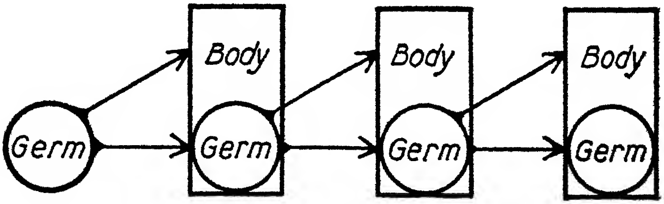


FIG 1.

The figure is designed to show how the germ cells derive their characteristics from *preceding germ cells* and to make clear why

it is that changes occurring in the body cells within the individual's lifetime are not inherited. The germ cells must of course be carried. nourished and supplied with oxygen; but most of the specific changes in the body, such as the changes in the brain, do not ordinarily affect the structure of the germ cell. Weismann cut off the tails of twenty-two generations of mice, and found the twenty-third generation with tails as long as ever. Children apparently take as long to learn to talk a given dialect as they did several hundred years ago, though each generation of ancestors learned the same dialect before them. A race of musicians such as the musicians of the German courts in the last few centuries is not the product of gradual changes in the germ cells due to the musical education which each generation receives and transmits through heredity to the next. It is of course a tremendous advantage to be born into a musical family. Probably, those who first came to the court as musicians were themselves endowed with unusual musical gifts, and there has probably been much intermarriage of such stocks. But all this is quite different from saying that musical training has a specific effect upon the germ cell What a child derives from heredity is not derived from the body cells of the individual father and mother, but from the germ cells. All the rest of the musical capacity of the child is the result of environmental influences such as the musical opportunities which the parents give This illustration seems to apply with equal force to all specific interests, tastes or purposes. We inherit the biological capacity to develop in a particular way, but this potentiality becomes an actuality mostly through the social opportunities which are thrown in the way of one individual and not in the way of another. Later on (Chapter XIX) we shall consider individual differences between human beings in their hereditary capacity for intellectual growth; here we are concerned simply with the basic laws of heredity as they affect all human individuals. In this connection it is important to note that the basic reflex acts, and emotions, and motives, which govern human beings as a group wherever they are, are determined in a fairly uniform way by the

basic characteristics of human germ cells. No matter how the germ cells may differ in determining such characteristics as musical or artistic ability, they seem to foreordain the simple reflexes, emotions and drives in about the same way for *all* human beings.

The laws of heredity are important in explaining the origin of human motives. The physical equipment which comes to us through heredity gives us a set of organs whose function is important in our motivation. We are hungry because of certain changes in our stomachs, and thirsty because of certain changes in our throats, and so on. Nature has provided definite physical structures in the body which in functioning "motivate" us, make us behave in one way or another. The basic motives which human beings have in common are inherited. An example or two will serve to show the point of view which biologists and psychologists take toward the explanation of our social motives. Let us consider the almost universal prevalence of superstitions based upon fear. We inherit tendencies to fear and to withdraw from things which injure us. Are superstitious fears due to the remembrance of the fears from which our ancestors suffered? Are we afraid of certain things because our ancestors suffered from them? Do we relive the experiences of our ancestors? Or, indeed, can the habits which our ancestors acquired in their lifetimes be passed on in specific form? The answer to all these questions is clearly in the negative. We do not inherit a large variety of *specific* fears. We inherit the tendency to fear, but *what* a man will fear depends mostly on his own personal experiences in his own lifetime. Most of our fears are picked up in social situations. They are acquired by each one of us as an individual. Even when we all have similar fears, the mechanism by which the fear of *specific* things—the devil, or typhoid fever—is handed on from one generation to the next is not a biological mechanism at all but is simply a social tradition. Instead of arguing that habits that are acquired by the individual are transmitted biologically to the offspring, we have many reasons to believe that children learn to be afraid of certain things because their parents tell them that these things are dangerous or because

of their own experience of pain or distress with these things. For example, generation after generation of children is fascinated by flames, but each generation has to *learn* through painful individual experience that fire burns and hurts. By the child's individual experience, or by being taught what he might expect to happen, he may develop a specific tendency to avoid fire, or foods which give him stomach ache, or situations which result in other kinds of physical harm.

Another illustration will be given from a recent magazine article which tells how colored people on southern plantations lapsed back into voodoo practices when they were isolated from the influence of the Christian Church. The author of the article thought that witchcraft was "in their blood" Fear of the dead and of the supernatural was thought to be in the very soul of the black man. But as a matter of fact we know of no possible way in which a man could inherit a tendency to perform voodoo practices or to be afraid of them If actual fragments of voodoo folklore have been passed on *by tradition* since the days of the earliest slavery on the American continent, these fragments might be revived, but the transmission in this case is social, not biological. Again, we are often told that our acquisitive instincts are stronger than those of primitive man because we have for thousands of years cultivated the practice of individual wealth-gathering and competitive barter and sale. It is of course true that we may have become more acquisitive through social evolution, but it is hard to see how an innate acquisitive tendency could change in a few thousand years unless somehow or other the struggle for existence actually weeded out those who had the instinct in a rather weak or undeveloped form. Biological changes as profound as these usually take hundreds of thousands of generations to be worked out; it seems a great deal more likely that we have become more acquisitive because our economic system has become more complicated and has given more opportunities for the development of acquisitive habits As a result of all these and other similar considerations, there is practically universal agreement that our

hereditary equipment differs very little, if at all, from that of the men of twenty or thirty thousand years ago.

Heredity and evolution depend upon the history of the germ cell.—How do hereditary traits arise? Like other variations which appear in plant or animal stock, this may be explained only in terms of *variation within the substance of the germ cell itself.* There are two ways in which such variations in germ cells may occur.

The first major cause of variation is recombination of the elements in the germ cells which determine the hereditary make-up of the individual. Within the germ cells of each sex are a number of *chromosomes*, rod-like bodies within which are contained still smaller elements called *genes.* The union of a sperm with an egg makes possible a new combination of genes, a combination which never occurred in history before. Each individual results from a complicated combination of genes from the two parents, but even if there are twenty children each will derive different hereditary elements because of the large number of genes involved and the many ways in which combinations of the genes in the two germ cells may occur Two brothers may be very dissimilar in physical, emotional and intellectual characteristics. In the long run they will be more alike than those who are not related, but the resemblance is far from perfect. We inherit, of course, not just from the father and mother but from the stock as a whole In this way a very large amount of variation between individuals with the same parents is possible. Even stock which is absolutely uniform at a given time and place might in a few generations diversify greatly. Some individuals might prove completely unfit in the struggle for existence. Others might be clinging on, despite difficulties, while still others might be succeeding excellently. Each new individual is like other members of his species in major structural characteristics, but each has a different gene combination which affects his appearance, size, temperament, speed of conduction in the nervous system and every other characteristic which he shows at birth or which may develop as the result of interaction between the organism and the environment.

The differences among the various kinds of dogs or pigeons are partly random and partly the result of deliberate selection and breeding by those who own them. The variations produced by selective breeding may be extreme. We may have dwarfs or giants, Pomeranians or Great Danes, dachshunds or chows or spaniels, but where a given pattern of genes has been achieved by inbreeding and selection in any given case, the limits of this type of variation are soon reached and no further changes of this sort can be brought about Such animals can be perpetuated only if bred with others of the same kind. Thus a race of superior human beings could be produced by stringent selective methods, but it would not be possible to secure a new type of human being in this way, for this type of variation does not lead to new species. It is not the kind of variation which has given rise to the new *types of organisms* which have appeared constantly during the long process of evolution.

The second source of variation is through *mutation*, that is, by the sudden appearance of an absolutely new gene in the germ cell. Experimental work (largely by T. H Morgan and his pupils) with relatively simple forms of life has yielded clear-cut facts about the way in which germ cells may give rise to *absolutely new types* of creatures The basis for these sudden changes or mutations is as follows. Within each germ cell there are, as we noted, rod-like bodies called chromosomes, in each chromosome there are tiny particles called genes. Since these genes are the true basis of heredity, a fundamental change in the species is only possible by virtue of the appearance of an absolutely *new gene* in the germ cell. A new kind of individual appears suddenly because a new gene within the chromosome has appeared suddenly. By microscopic studies it is possible to tell just where in a given chromosome the new gene has appeared In fact, mapping the chromosomes in this way has gone quite far. These new genes are the true basis for the new traits which organisms show. As a result of twenty years of breeding on the fruit fly, drosophila, about five hundred of these sudden mutations have

been observed. The new gene may affect the structure and behavior of the individual in any way. It may alter the length of wings, color of eyes, number of legs, and so on. Many of these mutations are harmful to the individual and may result in its destruction, but some are beneficial. Sometimes a mutation may give rise to a creature which can adapt itself in a new way to the environment and which will have a chance to compete favorably with other animals It may become the ancestor of a new species

Mutations are believed to account for all the new types of organisms and to be the basis for evolutionary changes. Not only may such a mutation give an animal a physical advantage, such as sharper teeth or longer legs, with an advantage in relation to the food supply, but it may give a sudden new kind of muscular development, a better method of conducting impulses through the nervous system or better sense organs for contact with environment Organs like muscles and nerves have come into existence through a series of favorable mutations The organs upon which our motives depend have come this same way The reflexes which protect us against many dangers by causing us to jerk back the hand, blink the eyelid, etc, have come about through the tremendous advantage which such new types of action had for the individuals which possessed them Mutations are not frequent in a given species, but in the long struggle for existence they are all-important whenever they permit a new way of adapting to environment. The laws governing mutations in the laboratory have a great deal in common with the general laws which govern their appearance in nature. It has recently been discovered that the frequency of mutations can be greatly increased by the use of X-rays, and it seems probable that there are rays or waves occurring in nature all the time which are capable of giving rise to mutations.

Our inborn tendencies therefore are not inherited habits. They are not due to what our ancestors learned. They are due to a long succession of mutations In other words, those mutations which

make possible an effective adaptation to the environment have been preserved.

Muscles, sense organs, and nervous systems have all developed through specialization of cells.—Through these laws of heredity and evolution, the different cells which make up the body have become specialized in various ways. At different times different cells have expanded or contracted, or have become heavier or lighter, or drier or wetter, etc. Three kinds of specialization which concern us most in psychology are those which have made individual cells capable of rapid change of shape so as to cause movement; those which have made them more sensitive to changes in the environment; and those which have made them capable of swift conduction from one point to another The first of these three changes led to the evolution of muscles, the second to the evolution of sense organs like the eye and ear, and the third to the evolution of the nervous system including the brain.

Muscles are older in the evolutionary sequence than either sense organs or nervous systems. Animals could move before they could select adequately or before messages could be efficiently relayed to different parts of the body Some of the muscles of the human body are still of a primitive sort. They are called "unstriped" or "unstriated" muscles because under the microscope they show none of the stripe marks which characterize most of our muscles. Examples are the iris of the eye, the walls of the arteries, and the muscles of the digestive tract These muscles have to do with very primitive but very necessary activities such as the contraction of the pupil of the eye in response to excessive light, the regulation of blood pressure and the conduction of food along the alimentary canal. Under ordinary conditions they are not under voluntary control at all. They are therefore also sometimes called involuntary muscles Other muscles are called "striated" or "striped" because under the microscope they show little stripe marks running at right angles to the line of the muscle fiber. They include most of the large muscles of the body, those involved in posture, walking, turning of the head

and all skilled movements They are sometimes called voluntary muscles because they are ordinarily under voluntary control. These are a later development and are not found in the lowest forms of life.

The evolution of sense organs came about through the increasing sensitiveness of certain cells of the body to certain kinds of stimulation. Cells which were slightly more sensitive to light specialized in this function more and more until a complex and efficient eye appeared. Each one of the sense organs is the end product of a long series of evolutionary changes, making it possible for the animal to respond more effectively than it could if the body remained equally sensitive at all points to every possible kind of change in the environment.

FIG 2. — Nerve-net (somewhat simplified) The black lines represent the nerve fibers. This primitive kind of nervous system connects nerve strands without providing specific pathways for each nerve impulse. Modified from A. Bethe, *Allgemeine Anatomie und Physiologie des Nervensystems*, Georg Thieme, p 90

The nervous system has shown specialization from mass action to capacity for reflex acts.—The earliest nervous system is, as Fig. 2 shows, a diffuse net-like structure to which the name nerve-net is given. The nerve-net of the jellyfish is illustrative. Here the impulse is conducted slowly in all directions from the point of stimulation. There are no specific pathways; the conduction is every-which-way and leads to "mass action." Such conduction is slow, wasteful, and clumsy. In the course of evolution the nervous system has specialized more finely More definite pathways have gradually evolved from the nerve-net, connecting one point specifically with another More and more specific pathways have appeared, leading from sense organ to a central connection and out to a specific group of muscles. In these specific pathways, fibers connecting sense organs with centers in the nervous system are well insulated from other fibers, and those fibers which conduct from the centers out to the muscles are equally well insulated Human behavior depends in the last analysis upon connections between our sense organs and our muscles.

We react as we do because evolution has provided us with pathways which insure that we shall respond appropriately.

The nervous system, however, has done even more than this. It has provided the basis for a vast system of interconnections between different kinds of responses. These interconnections between different responses make it possible for us to *learn*, that is, to behave in ways which nature has not specifically laid down The ability to learn is one of the richest of the products of evolution, and since this ability to learn depends so largely upon the brain, it is worth our while to study closely how this brain develops in the individual. This we shall do in the following chapter.

SUMMARY

Human nature is understood in the light of its development. Both our motives and our capacity to learn are products of evolution. The most striking characteristic of man is his capacity to learn, which so far surpasses that of other animals that it enables him to use symbols. Evolutionary development includes the development of sense organs, muscles, and the nervous system. The nervous system has progressed from mass action to specific reflex action All these developments, including the development of reflex action, have resulted not from ancestral habits but from mutations in germ cells. Our motives, reflexes, and capacity to learn provide important parts of the "raw material of human nature." This raw material inherited by the child is shaped by the civilization in which he grows up.

REFERENCES

Conklin, E G, *Heredity and Environment* (6th ed.), 1927

Gault, R. H., and Howard, D E, *Outline of General Psychology* (2nd ed), 1933, Chapter II

Herrick, C J, *Introduction to Neurology* (5th ed), 1931

Ladd, G T, and Woodworth, R S, *Elements of Physiological Psychology*, 1911, Part I, Chapter I

McDougall, W., *Outline of Psychology*, 1923, Chapter II

Parker, G H, *The Elementary Nervous System,* 1919
Warden, C J, *The Evolution of Human Behavior,* 1932.
Warren, H C., and Carmichael, L, *Elements of Human Psychology* (rev ed), 1930, Chapters II and III
Washburn, M F, *The Animal Mind* (3rd ed), 1926.

PROBLEMS

1. If psychology is a laboratory science, why is it necessary to inquire about man's remote past?
2. Does the explanation of all psychological events lie in biology? From what other sources does the student of man draw material? Is he justified in doing so?
3. Does evolution mean, as we have seen it here, continuous progress toward a more and more nearly perfect adaptation to environment?

CHAPTER III

THE INDIVIDUAL ORIGIN OF BEHAVIOR PATTERNS

THE development of behavior patterns in the race has suggested the conclusion that most development involves specialization. Growth is from the simple, unspecialized organism to the complicated, specialized organism which has division of labor among its various parts. The same kind of evolution is found in the nervous system of the growing *individual*; all the higher forms of life show, as they grow, the same progression from mass reactions to specific reflexes. For each month or week of development, it is possible to define a stage in the process by which the nervous system has taken on more specific functions. Human nature is best understood if it is seen as it *develops*. We shall have much to say in a moment about the growth of children, but we can also learn much about the laws of growth by studying carefully the growth of individuals of other species

Human beings and animals develop from general response to specific response.—Even kittens can teach us a good deal. Experimental study shows that relatively few of the many reflex acts which the adult cat can carry out are present at the time of the kitten's birth Day by day, one function after another appears. Thus on the ninth day after birth, every individual kitten among a large number could stand up Kittens can raise themselves on their forelegs in their first few days of life, but the reflex pathways for getting up on the haunches are not mature until they are nine days old. It is just as if the central nervous system had a timing device, a sort of clockwork, which controlled the functional maturing of various specific parts of the nervous system which are necessary for different reflexes. Gradually, in place of mass response, specific reflex acts appear. This is possible because differ-

ent parts of the central nervous system are becoming mature, providing a physical basis for the reflex response. The anatomical development of the animal's nervous system is the only necessary condition for the appearance of the new functions. This has been shown by Coghill in a series of careful comparisons between the degree of anatomical development of the nervous system and the degree of functional capacity in various animals. Stage after stage in functional adjustment appears exactly at the time when appropriate anatomical details become mature in the growing embryo. This appearance of new functions is called *maturation.* The development of many specific functions to replace mass response is called *individuation.* The method of differentiation within the nervous system and certain stages of development are shown in Fig. 3; they serve to explain the appearance of new activities from time to time. The black portion is white matter in the nervous system (stained). From generalized chaos a large system of definite pathways has emerged, and the *stages in the development of the nervous system* correspond to *stages in animal behavior.* The fact that characteristic behavior appears on the ninth or on the thirteenth day fits in with the fact that nervous pathways have become ready to function on those days.

Much behavior which is popularly attributed to learning is really due to maturation.—The healthy animal practices its capacities as fast as they appear. As it grows, improvement in simple acts like standing, running, following objects with the eyes, and so on, depends partly on growth, partly on practice; and in this respect human infants are similar to other animals. To study maturation properly, it is important to know the exact influence of the *environment.* In order to keep the influence of environment constant and to prevent the possibility of learning, tadpoles were placed in a solution containing an anæsthetic which kept them as motionless as if they were dead. Under these conditions they went on growing and their nervous systems went on providing more and more definite pathways between sense organs and muscles. When the tadpoles were transferred to fresh water at the time when tadpoles normally begin to swim, the swimming

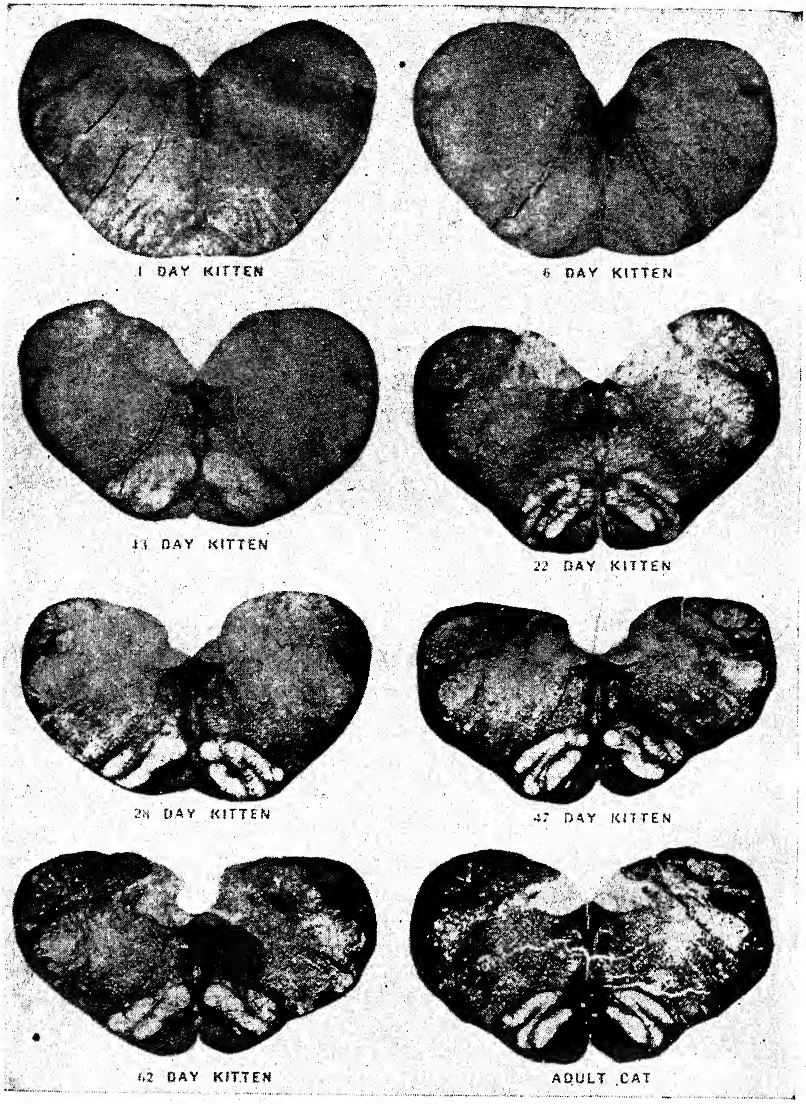


FIG. 3.—Maturation in the cat's brain. Sections across the brain, near the spinal cord, were cut in kittens of different ages and then prepared with a stain. The stain causes the "myelin sheath" to appear black in the figures. Nerve fibers without this sheath are incomplete. The black portions therefore represent specialized pathways. Note that at first only the vague general outlines appear and that as the animal gets older more and more specific details of nerve pathways develop, indicated in the pictures by increasing amounts of black. From F. Tilney and L. Casamajor, *Arch. of Neurol. and Psychiat.*, 1924, vol. 12, p. 9. By courtesy of the editor and authors.

movements were found to be absolutely normal for the species from the very start Other tadpoles removed from the anæsthetic before the normal time of swimming remained perfectly still. It is not possible to explain the coordinated movements in terms of mere practice in swimming, because coordination is complete when it first appears. This process of maturation is much harder to study in human infants but there are numerous cases in which the performance of an act is almost perfect when it first appears, and we shall pay attention to these cases in a moment. Maturation in the nervous system can be sudden, definite and complete, whether a simple reflex or a complicated one is involved.

We have just described a case of maturation in a growing animal. In the case of the higher forms of life including man, some of the most important stages in growth are completed before the time of birth. From many studies of animals prematurely born, it has been possible to show that the maturation process goes on *before* the normal time of birth in just about the way that it continues *after* birth. For example, the guinea pig, the normal gestation period of which is sixty-eight days, has been removed at the 66th, 64th, 60th day, etc., and tested for reflex functions, with the result that the same uniformity from animal to animal has been discovered as was discovered in comparing individual animals at various times after birth It is clear that the nervous system has been specializing before birth just as it continues to do thereafter. Indeed, looked at broadly from a biological point of view, it is clear that the fact of birth at a given time has but little effect upon the maturation which is going on constantly in the nervous system.

Maturation is just as important in human behavior as in that of animals.—Do these principles apply to human beings? They do, and in a very striking way Both before and after birth there is a series of progressive changes

The stages in this progression are not hard to define. During the embryonic period there is in general a tendency toward mass response, the individual reacting more or less as a whole. It might

remind one of the mass response due to the simple nerve-net of the jellyfish, described on page 33. But in the later months approaching the time of normal birth, the nervous system has specialized itself for the production of more definite reflex responses. At the time of birth there is still a good deal of mass response. Behavior seems chaotic. The mass activity consists of imperfectly coordinated stretchings, kickings, slashings of arms and legs, the twisting and turning of body and trunk, pushing up the head, turning from this side to that, rolling, thrashing, wriggling in every direction This kind of diffuse activity is evident in the face—grimacing, wrinkling of nose, pursing of lips, all without definite pattern or fixed relation to one specific stimulus as compared with any other stimulus. This kind of mass response appears both when the infant is left to itself in quiet and comfort and when it is stimulated by the experimenter. Holding the infant's nose, tickling the sole of his foot, sticking him with a needle are all apt to produce thrashings or kicks in more or less equal amount. Even the cry of the infant seems for the most part an aspect of mass response. The cries of hunger or pain are like the kicks and writhings which appear through the infant's whole range of diffuse response.

This "chaos" in infant behavior is not of course due to a real lack of *causes* of response Responses are not really "random." In the nervous system of the little child there is a network of interconnections far more definite than that shown in the schematic diagram on page 33 for the jellyfish, but still very much *less* specialized than the nervous system of an older child or an adult. There are definite laws of development in the nervous system relating to *progression from mass responses to specific reflex responses*, and infants are all very much alike in their conformity to these general laws. Even at birth many specific action-systems are ready to function if one knows how to bring them out. The nervous system, and consequently the behavior, is more specialized than it was in the embryonic period (as can be shown by comparing the normal nine-months' baby with a premature baby). It

requires a careful technique to show just what reflex responses can really be said to be present at birth. Figs. 4a and 4b show two types of complicated reflex activity which the nervous system is ready to carry out, which are often obscured by the sheer weakness of the little child, its inability to raise itself and carry through muscular activities. Many very young infants can make these walking and crawling movements if their weight is supported. Only the best experimentation can determine whether an infant's new response on a given day is primarily a product of experience or

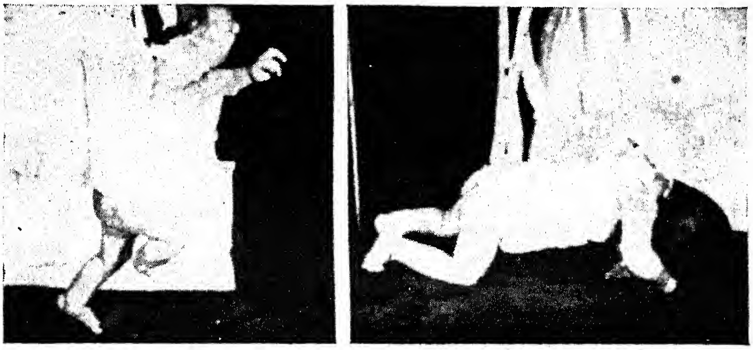


FIG. 4a.—Infant, three days old, taking walking steps while supported.

FIG. 4b.—Infant, three days old, making crawling movements with arms and legs while supported.

These figures show how some patterns of action may be ready in the child before they are ordinarily brought into play. From L. B. Chaney and M. B. McGraw, *Bull. Neurol. Inst. of N. Y.*, 1932, vol. 2, p. 37. By courtesy of the authors and the Neurological Institute.

primarily an emerging unit, depending directly upon the development of the nervous system.

We may speak of such specific responses as appearing on the stage week by week or month by month for at least two years of life. Though there are wide individual differences in detail, the general sequence of progression was found to be fairly uniform for a group of twenty-five babies who were recently studied intensively in Minneapolis. Fig. 5 shows the general order of development which was found. It seems very unlikely that learning would produce the same pattern of growth in these infants.

This is more like the sequence of activities which we should expect from sheer development of the nervous system.

Learning is of course going on all this time; by means of learning, certain reflex activities may be combined. The infant who responds with both arms and legs may learn to combine these

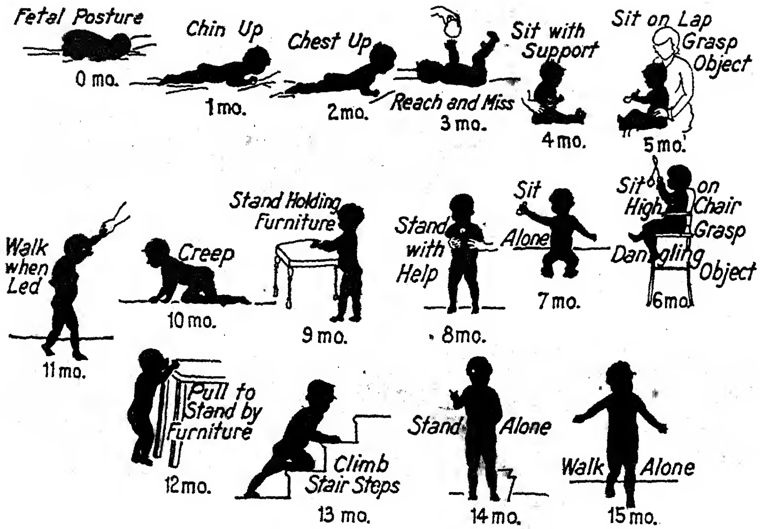


FIG. 5.—Motor development of the child. This is a typical sequence of development of these forms of behavior in children. The ages shown in the chart are rough approximations, based on the observation of twenty-five children, and are designed to show the *general order*, not the exact time, of development. Frontispiece from Mary M. Shirley, *The First Two Years. A Study of Twenty-five Babies,* Vol. II. *Intellectual Development.* The University of Minnesota Press, Minneapolis, 1933. By courtesy of the publishers and the author.

movements. Even in such cases, however, it would be a mistake to assume that *every* new combination of movements is due to learning, without taking account of the frequent appearance of new forms of behavior as a result of maturation. An example of maturation mixed with learning appears in a study of coordination of the eyes and the ability to reach for objects, made on about three hundred babies in New York, the tests being given over and over again from the earliest weeks to about the eighth month after birth. Fig. 6 indicates that larger and larger numbers

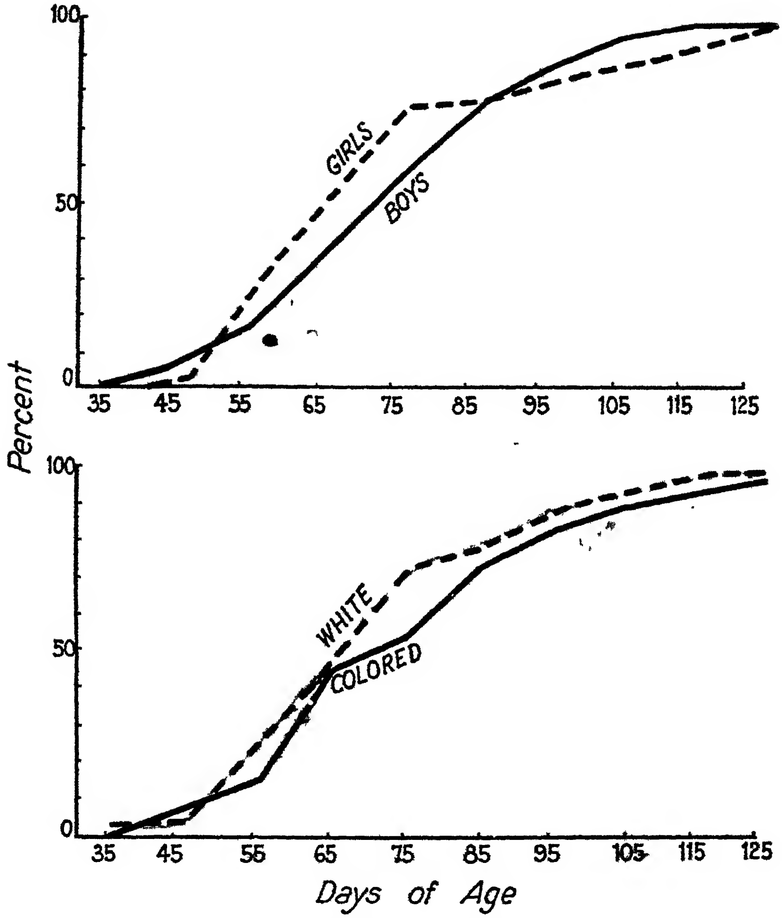


FIG. 6.—Development of eye-coordination. This graph shows what percentage of the children were able, at different ages, to follow a light when it was moved up and down The base line, or horizontal axis, of the graph indicates ages of the children observed. The upright, or vertical axis, is divided into percentages. Any point on the graph-line is plotted with reference to both the upright and the horizontal lines, and indicates two things—in this case, percentage of children and age level, or what percentage of children were successful at each age level *In reading any graph, it is necessary to understand what the two lines of reference (the horizontal and vertical) stand for, then any specific point on the graph-line can be interpreted, and by observing the general trend of the curve one can see the relationships between the two things which are being studied.* Here one sees that it was about the 45th day before any of the children showed the response and that by the age of about 125 days the reaction was present in all the children, the general form of the curves shows that there is no significant difference between the groups being compared, but that eye coordination increases as the *infant grows older*, and is present in all normal infants at 125 days. From M. C. Jones, *J. Genet. Psychol.*, 1926, vol. 33, p 554 By courtesy of the editor and the author.

of children were able to pass these tests as age increased. The curves show the total number of all those who had mastered the response at the time of each observation At sixty days the number is small At ninety days it is much greater. The second turning of the curve shows that nearly all are accounted for. The curve tapers off to a level as the last few fall into line. Certainly the ability to reach for an object which the child sees depends largely upon learning, and even the coordination of the eyes is influenced by learning to a considerable extent. Both of these activities depend also upon the growth of eyes and hands, and of the nervous system which furnishes the connections between eyes and hands, so that maturation and learning are interwoven. In most everyday situations, and even in many laboratory situations, we can only note how such functions involve *both* growth and learning, inextricably intertwined.

But for scientific purposes it is nevertheless extremely important to find out how much of human growth is taken care of by nature and in what respects special training is necessary. If we wish to know what elements in human nature are more or less "inevitable," we must find what elements appear no matter what the social environment is. Specific hereditary responses of this sort are called reflexes (cf page 22).

The following partial list will be suggestive of the kinds of activities which we group under the name reflex. breathing; sucking; swallowing; sneezing; coughing; the stretching out or pulling back of the arms and legs; fixation of the eyes upon a light; crying; starting; babbling; blushing.

Reflexes depend on: (1) receptors, (2) afferent nerve fibers, (3) central connections, (4) efferent nerve fibers, (5) effectors.—What is the physical basis for all these responses? We have noted that the end result of maturation is a reflex. Under ordinary conditions the thing that stimulates a muscle is activity upon a sense organ and the series of changes which follow such stimulation. The sense organ, or receptor, is connected with a nerve cell, or *neurone*, which is a body cell specialized for swift conduction (pages 32-33). Compare A in Fig. 7. Neurones carry

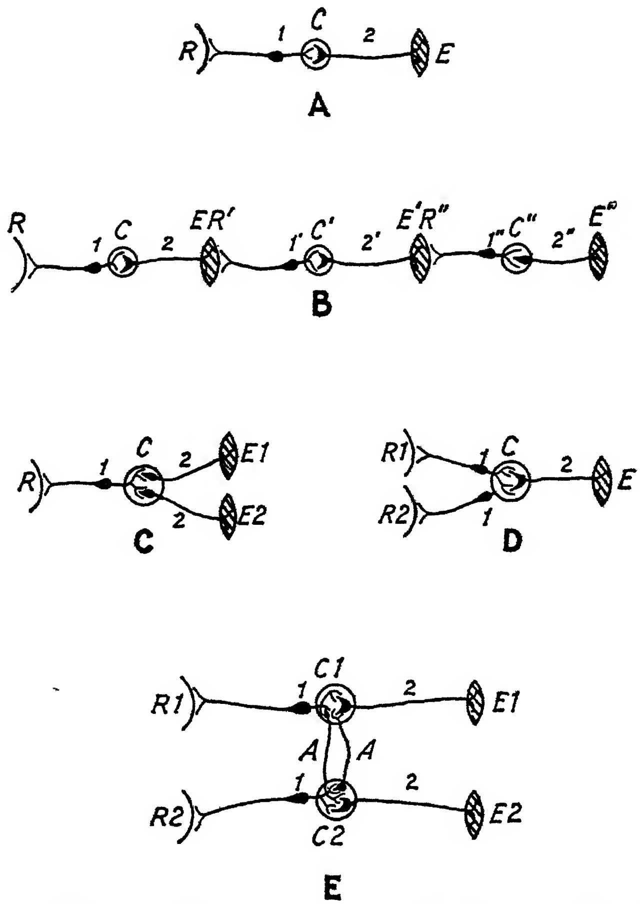


FIG. 7.—Five types of reflex arc In each of the diagrams, *R* is the *receptor* or receiving cell and *E* is the *effector* or responding cell. The incoming (afferent) nerve fibers which bring the impulse *in* to the center of the reaction are labeled 1 The outgoing (efferent) nerve fibers which carry the impulse *out* are labeled 2 Nerve fibers are called axones There are many *nerve fibers* which run parallel inside of every *nerve*, a nerve is in this way like a cable.

A. Simple reflex where only one receptor and one effector are involved. Stimulus at *R* makes nerve fiber 1 (the afferent neurone) active At *C* the next fiber in the chain, 2 (the efferent neurone) becomes active and stimulates activity in *E* *E* is the effector, the responding cell, and in this diagram the activity thus aroused is the response to the stimulus

B. A chain reflex in which the activity of the first effector serves as a stimulus for another receptor, the reaction to which stimulates still another system.

C A single stimulus at one receptor sets two effectors into action.

D Stimulation of two receptors results in exciting only one effector.

E. Two associated reflex arcs are shown Stimulation of either receptor may excite the activity of either or both of the effectors through the association neurones *A*

From C J Herrick, *An Introduction to Neurology,* 5th ed , W. B. Saunders Company, p 66 By courtesy of the publishers.

the impulse out to the muscles and cause them to contract, bringing about the movement. This is the very simplest kind of conduction in the nervous system. Fig 7 shows several other simple types of reflex arcs—paths conducting from sense organs to muscles. Usually there are still more complicated connections which are used in the transmission of such nerve impulses When the reflex occurs at a different level in the body from the one at which the stimulus acts, up-and-down connections are necessary, as Fig. 8 shows; the up-and-down connections are somewhat more complicated than when the response is at the same level as the stimulus Note these frequently used terms: An individual nerve cell is a *neurone*, there are *sensory neurones* which bring in messages from the sense organs; there are *connecting neurones* in the brain and spinal cord, and there are *motor neurones* going out to the muscles. The connection between neurones is a *synapse.* Receiving cells are *receptors.* Response cells are *effectors; effectors* include both *muscles* and *glands.*

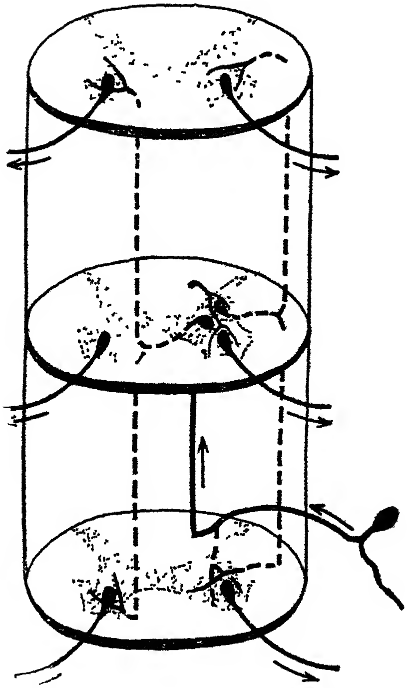


FIG 8.—Diagram of some reflex paths in the spinal cord The solid lines show the incoming and outgoing neurones The nerve fibers represented by broken lines are the fibers which connect different levels of the column so that an impulse from a stimulation at one part of the body may produce a response such as the moving of a muscle in another part Here only three suggested levels of the spinal column are shown, it must be remembered that the column extends up into the brain and that the reflex arcs shown are only simplified ways of showing the mechanism of the thousands of complex patterns which may occur From E Villiger, *Brain and Spinal Cord,* Wilhelm Engelmann and J B Lippincott Co, p 192 By courtesy of the publishers

The simple reflexes mostly depend directly upon the spinal cord, whereas the more complicated muscular responses depend upon circuits *passing up and through the brain.* Sometimes reflex action is so quick and sure that the more complicated activities in the brain cannot stop it. Thus the reflex twinge to the dentist's manipulation may be so quick that all attempts to control our movements are ineffectual. Nevertheless, every sensory neurone carrying an incoming stimulus connects with neurones which go up into the brain, and the brain, by means of other neurones passing down, may reinforce or check many reflex activities. You can hold your hand in water which is disagreeably hot without making the reflex response of jerking it back, and if something important is at stake you may be able to control even some of the most dependable reflexes. Sherrington showed that the brain influences simple reflexes by making the synapses function more easily in some cases and with greater difficulty in others The general relations of the brain, the spinal cord and the nerves are shown in Fig 9 (Each nerve contains many nerve fibers running parallel as in a cable, and the brain contains billions of nerve cells.)

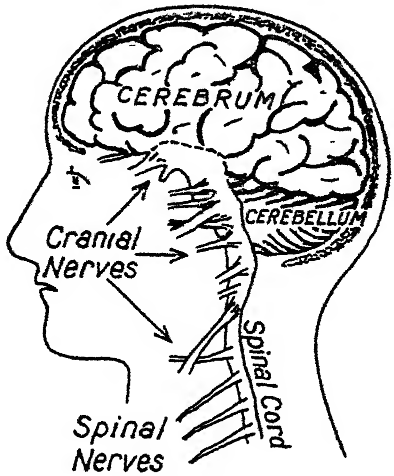


FIG 9—Diagram showing the relation of the spinal cord to the brain The cerebrum, within the skull, is merely the upper end of a long and intricate system The spinal cord runs down the back of the body within the protection of the spine, or backbone At the upper end it leads into the brain stem, from which the labeled cranial nerves are seen to come

No reflex ever functions in complete independence of the rest of the body.—The fact that reflexes depend on the activities of the higher centers is an example of the fact that they are a part of the unified life of the whole organism. Sherrington, the greatest

of modern experimentalists in this field, calls the simple reflex a "convenient abstraction." Yet such a concept is useful in giving an idea as to how it is possible for light acting on the eye to cause the muscles of the iris to contract, or how it is possible for a man to keep his balance when walking on an icy street against the wind; nature has equipped us with an intricate system of receptors and effectors which can be depended upon to do their work with reasonable efficiency Nevertheless, the organism has to work as a whole, and the richest gift of nature to man is the great system of interconnected nerve cells in the brain which make possible the formation of new associations and the adaptation to new situations.

Psychologists use the term *threshold* to define the amount of difficulty encountered in bringing about a response. The analogy for this term is drawn from the threshold of a room. If the threshold is low it is so easy to step from one room to the next that one thinks nothing about it. If the threshold is higher, one has to lift the foot higher to clear it In the blockhouses of the frontier built for defense against the Indians, the thresholds were sometimes extremely high; only a tall man could step over easily We think of the synapse as having a variable threshold. When it has a low threshold, impulses coming along a nerve fiber get through the synapse and stimulate the next nerve fiber. When the threshold is high, the same stimulus will not be able to get through. Various common drugs like caffein and strychnine alter thresholds. So does fatigue. Furthermore, the activities going on in the brain are constantly affecting the thresholds of particular nerve pathways, making some acts sure to occur and others equally sure not to occur An easy way of testing a reflex, and hence the threshold, is commonly utilized by the physician who taps your knees with a little rubber-headed hammer to see whether your "knee jerks" are normal If you pay too much attention to him and begin to wonder whether the reflexes will occur, they may fail to appear altogether; but if you look out of the window and take no interest in the matter the knee will usually jerk. This means that

your brain influences the reflex centers in your spinal cord. If the knee jerks are not very apparent, it is only necessary to clasp the two hands together, turn the elbows outward and pull hard; the knee jerk will be greatly reinforced. Knee jerks show the way in which the whole body influences a single response.

All this goes to show that the reflex, even after it has differentiated itself from the "mass response" found in the embryonic period or early childhood, and even after it has become highly specialized, still shows a great deal of dependence on the activities of the whole body. Every reflex is influenced by everything going on anywhere in the body and particularly by what is going on in the higher centers of the brain Every thought, every emotion, every effort affects the thresholds for all the reflexes.

It might be tempting to use neat analogies from architecture and to think of the body as if it were a building made up of separate stones placed in the proper relation to one another. If this were true, it would be easy to study human behavior by studying each simple reflex act, and then to show how, as the individual grows and learns, he puts these acts together into such complicated things as walking, skating, talking or conducting an orchestra. Unfortunately for this analogy, organic systems such as the body are not built as the architect builds. Bricks or stones have fixed structural characteristics which reflexes do not possess. The forms of integration need to be directly studied for their own sake, and the parts must be seen as aspects of whole systems rather than as having a fixed independent status free of the influence of other activities. All behavior is in a very real sense the behavior of the whole individual. In many places in the book we shall discuss separate acts (carried out by specific parts of the body), but it is worth while to note that even these isolated acts can be carried out only because of favorable conditions existing in the brain or in the body as a whole. Each act reflects the whole human being. Moreover, growth and learning go on simultaneously, so that the actions we see in daily life are a mixture of the two. An understanding of maturation will prove useful in study-

ing motives and emotions, but every form of behavior is complicated by the fact that the organism is *learning* while it grows, and *growing* while it learns

SUMMARY

Each human being as an individual develops from mass action to specific reflex action. This development from mass response to specific response as a result of growth is called maturation Maturation is due to the specialization going on in the nervous system of the growing individual The result of this growth is reflex behavior, which depends on pathways from sense organs through the central nervous system and out to the muscles, but every reflex act is affected by the entire condition of the body While growth and maturation are going on, the child is also learning, both maturation and learning must be carefully studied if the personality of the adult human being is to be understood

REFERENCES

Achilles, P S (Ed), *Psychology at Work,* 1932, Chapter I, by L H Meek, and Chapter II, by A Gesell

Buhler, C , *The First Year of Life,* 1930

Gesell, A , *Infancy and Human Growth,* 1928

Ladd, G T , and Woodworth, R S , *Elements of Physiological Psychology,* 1911, Part I, Chapters II, III, IV, V, VI, and VII

Murchison, C (Ed), *A Handbook of Child Psychology* (2nd ed), 1933

PROBLEMS

1 What reflexes and coordinations are involved in the behavior at different month levels which are or could be used as the basis of tests for infant development?

2 What comment would the highly specialized and coordinated refle behavior of ants lead you to make on the thesis that "the higher the

animal in the evolutionary scale, the greater the progress of individuation from mass behavior"?

3 Would you consider the behavior of adults or that of young children to be more dominated by specialized reflex reactions? How do you fit your answer into the description of the development of behavior in the individual as described in this chapter?

4 Do behavior patterns emerge all at once in any individual child, or can the pattern be said to emerge gradually? Can this be tested without regard to the influence of experience and learning?

5 Would you expect to find important individual differences not only in the time of appearance, but also in the actual character of basic behavior patterns?

CHAPTER IV

THE SIMPLER MOTIVES

IN THE preceding chapters we have suggested part of the answer to the question: How do human beings become the complicated personalities that we know them to be? We indicated some of the paths that must be followed if one wishes to observe the important turning points in human growth It is necessary to study many individuals and to note the similarities in their development in spite of the individual differences in their environments. We saw that progression is in general from vague generalized responses to specific and definite acts.

Most of these specific acts, however, have been considered as responses to *external* stimulation. We have not yet considered the *internal* factors which guide and shape our responses. These will be our next problem. We shall try in the next few chapters to suggest how the psychologist answers the question: Why do we carry out sustained activities, plans or purposes? What is there in us which drives us to act as we do? What are the inner factors which must be known if response to external stimulation is to be understood? The man who asks such questions regarding any act by another person usually says that he wants to know the *motive.* Psychologists have found it convenient to use this same term—applying it even more widely than most people might consider legitimate The term motive in ordinary usage suggests a conscious purpose, whereas the psychologist includes under this term all *basic tendencies to action*, or *"drives,"* whether we are conscious of them or not. He includes everything that drives toward action, and will try to see the psychological aspects of motive in relation to the changes in the body which play the chief rôle in determining them Our purpose is to study some of the experimental work on the more prominent patterns of motivated

response. Rather simple, biologically obvious motives and emotions will be considered in this chapter and the next. The more complicated ones depend upon so many psychological factors that we shall be able to consider them only when nearing the end of our survey of psychology, when we have come to the study of personality as a whole.

Most of the simpler motives depend on bodily rhythms.—Most of the simpler motives, like hunger, thirst and sex, are governed by changes in the vital organs—the *viscera.* Among all the higher forms of life, and obviously indeed in man, there occur rhythmical changes which are among the most conspicuous causes of motivation. The way in which these rhythms determine motives may best be brought out by considering first the nature of hunger, a motive so universal and so important that practically everyone will agree on its prominent place among human motives. It may be studied in various ways. As a man lies asleep, periods of restlessness occur at fairly regular intervals. The restlessness lasts for a few seconds or a minute or two, then the man is quiet again; then the restlessness reappears. For a given individual these moments of restlessness are spaced so evenly that we should expect to find definite bodily causes. Experimental study shows that these moments can be grouped according to a number of definite causes, of which one is the rhythmic contraction of the stomach. These hunger contractions start and stop again at regular intervals throughout the night

This rhythm which underlies hunger can be studied also in waking subjects in the laboratory After a tiny balloon has been swallowed and inflated in the stomach, the subject is asked to tap a telegraph key whenever he feels the pangs of hunger. When the stomach contracts, the balloon sends an air current through a tube which activates a marker on a rotating smoked drum The hunger experiences are found to coincide almost perfectly with the moments of violent stomach contraction which are recorded by the apparatus. Hunger is thus found to be not just a general state of discomfort, but a specific experience depending upon a specific activity in the digestive tract. These contractions are in

fact different from, and much more vigorous than, those which occur during actual digestion Further experiments with X-rays where opaque substances have been mixed in the food have shown the relations between *hunger experiences* and *stomach contractions.* The experience of hunger is so dependent upon these contractions that persons who have gone several days without food, and whose stomachs have adjusted themselves to its absence and ceased contracting, frequently experience no hunger whatever.

Hunger, however, is more than a mechanical matter depending upon rhythmical muscular contractions. We must next explain the reasons for these contractions, the way in which they are produced by the nervous system, and the general state of the body which makes the nervous system act as it does

Students of the chemistry of the body have shown how the various substances carried by the blood help to determine whether the stomach muscles will contract or not. The amount of blood sugar available plays some part, since the using up of this important substance tends to start the hunger contractions. But hunger is not just a question of a *lack* of certain necessary food substances in the blood supply. A definite substance is liberated into the blood by bodily tissues which are "hungry," and the chemical changes which are set up in this way make the nervous system start the stomach muscles contracting For example, when a small quantity of blood was drawn from a starving dog and injected into a dog which had just finished a meal, the latter jumped up and started eating again The "hungry" blood contained something which could start hunger contractions even in a different animal

Chemistry is therefore an important clue, but we must add that every motive is affected by learning We get hungry at meal time through force of habit, i e, the stomach has learned to begin contracting Even a very fat man who is in no need of nourishment may have intense hunger at his accustomed meal time; the nervous system activates the stomach no matter what the immediate chemical condition of the body may be

Thus far we have considered hunger in relation to internal

changes. In addition to the mechanics and chemistry of the matter, other important details must be mentioned. For example, when hens had eaten all the grain they wanted and would eat no more, particles of the same grain but of different *color* were given them They recommenced eating and ate for a long time. In other experiments, hens which had eaten their fill were put into the same room with others which were still eating. They plunged in again and ate as if they were intensely hungry Change in the outside stimulus, though it may appear to bear no relation to the internal changes which we call hunger, does nevertheless change the tendency to eat Motives are thus satisfied only in relation to a specific stimulus Organic condition may lead to quite different behavior when the external situation is different. No one part of the body determines the response; the whole organism must be studied Human beings react differently to new stimuli. Not only can new foods make us hungry again; all sorts of motives which have gone stale or flat can be aroused again by slight changes in the stimulus

Thirst is found in animal experiments to be just as rhythmical as hunger; the rat drinks about once an hour This is the response to a certain amount of water deficiency in the tissues That this is a matter of the body as a whole is shown in human subjects by the fact that the parched feeling in the throat disappears when water is injected into the veins. Of course, the membranes of the throat are more irritated by drying than are most other parts of the body; they *record* the existence of a condition which is really a condition of the body as a whole Thirst may be temporarily removed by painting the throat with cocaine, but when the drug wears off thirst returns. Thus the experience of thirst is not the *direct* result of a general bodily condition but the result of local changes in the mouth and throat These last, in turn, have been shown to depend directly on other bodily changes, namely, the failure of the flow of saliva Saliva normally keeps the mouth and throat moist, and as the body's water supply fails, the saliva is able for some hours to supply the necessary moisture. The body reserves of fluid, however, are in time used up and the

salivary glands begin to fail too An experimenter took no water from 7 p.m. until 3 p m the following day. During the last few hours of this time the salivary flow quickly fell off, and the sensation of thirst developed rapidly

The simpler motives of animals, such as hunger, thirst, and the sex and maternal drives, are studied with the activity wheel.—The relation of the condition of the organism to any particular response which it makes is suggested by a study of the kind of activity to which hunger leads. Hunger is one among many motives which, unless one has learned how to satisfy them, simply produce general *restlessness.* The periods of activity and quiet are so definite and so easily recorded that standard methods have been devised to measure their intensity, as well as their variation from time to time, in laboratory animals. For this purpose the activity wheel is used; cf. Fig. 10. This is like a squirrel wheel attached to a small cage When the animal is restless, it moves from the cage into the activity wheel, runs a while and comes back to the rest cage An automatic counter records the number of revolutions of the wheel (in either direction) The same standard cage and wheel has been used in studying many different motives or drives.

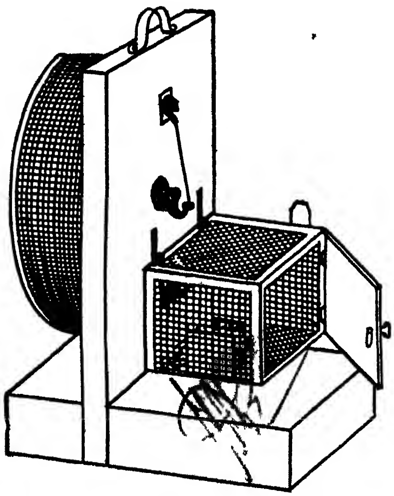


FIG. 10—Activity wheel This apparatus is used to measure general restlessness in animals, especially as a rough indicator of a drive The animal lives in the small square cage When he becomes restless he goes into the wheel through a small opening and runs, as on a treadmill The number of times the wheel goes round (in either direction) is automatically recorded by means of the slender rod from the wheel support to the automatic counter above

Why do we use animals for these studies of bodily rhythm? For one reason, studies of animals supplement our information regard-

ing human beings and frequently suggest problems which can then be studied more efficiently with new groups of human beings. We can, for example, subject the rat or even the dog to laboratory conditions which would be monotonous or oppressive for human subjects, and then test out on human beings the new principles which we have discovered, having isolated some of the things which are important to control and to test. In these simpler drives the similarities between human beings and the higher animals are generally very striking and the differences slight. In the case of the more *complicated* motives, great differences appear because of the greater rôle played by learning and by the influence of social usage and group standards of behavior. We regulate all human drives to some degree. In some drives, such as the sexual and maternal, social factors are so tremendously important that it is hard to trace out the simplest and most elementary forms of these activities In the case of hunger and thirst, however, we can discover the most important facts without such serious difficulty

To continue the study of rhythmical drives: In female white rats there is a rhythm of restlessness every four days which is directly connected with ovulation; there are also rhythms connected with care of the young, nest building, burrowing and migrating. In some cases these drives are so clear-cut that it is possible to disentangle them experimentally. If one finds a rhythm for which one knows no cause, it is possible to note the animal's habits and operate upon it surgically to find out exactly what is the cause Recently Richter at Johns Hopkins noted an activity cycle which seemed to have some definite relation to a small gland inside the skull known as the pituitary body. This gland is ordinarily controlled partly by brain activities; but Richter decided that if its stalk, which connects it with the brain, could be cut in such a way as to free it from control by the brain, its importance in relation to the activity might be shown more clearly. The results of this operation gave startling confirmation of this theory When the stalk of the pituitary body was cut, the slight variations in activity became much more sharply defined, as

Fig 11 shows In this way a relation was revealed between the pituitary body and one of the activity cycles Presumably the whole realm of the simpler motives could be worked out in some such way as Richter has suggested, if we knew exactly how to operate on the various parts of the body which serve to determine them In human beings, however, we should of course have to remember that all these motives are greatly affected by habit and by our social surroundings.

The glands of internal secretion are important sources of motivation.—The pituitary body is one of the *glands of internal*

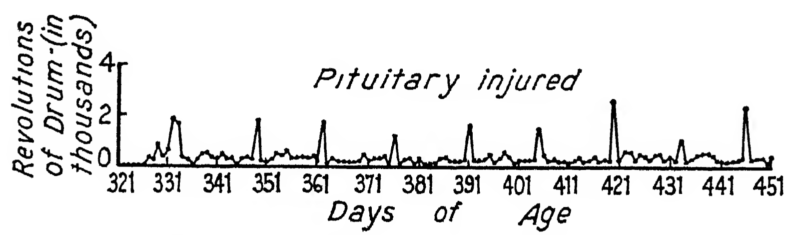


Fig 11.—An activity rhythm related to the pituitary body. The graph shows the activity of a rat The animal had been operated upon and the pituitary body injured The recurring jumps in the curve represent increased activity. Such rhythmic behavior is related to a body rhythm which here must be explained in terms of the influence of the pituitary body From C. P Richter, *Amer. J Orthopsychiat*, 1932, vol 2, p 349 By courtesy of the editor and the author

secretion. All body cells give off fluids directly or indirectly into the surrounding tissues. Some are more specialized in this respect than others A gland is simply a composite of cells which are specially active in such "secretion" Some glands are provided with ducts which lead their secretions to particular points; here belong, for example, the salivary glands and the sweat glands. Others spread their secretions directly into the nearby tissues, whence they are collected and circulated by the blood and lymph. These ductless glands, or glands of internal secretion, or endocrines, are of great importance in relation to the entire body chemistry, and seem to be both directly and indirectly connected with motives, emotions, and with more complex aspects of personality. Certain types of activity, both general and specific, may be directly affected by them

The endocrines exert their influences in the following way: It will be remembered that every impulse from sense organ to muscle has to pass a threshold in the nervous system, or a number of such thresholds The endocrine glands act to lower or raise thresholds for various kinds of responses. Even restless behavior may be regarded as a response to something, to the many slight pressures or sounds or lights which are always stimu-

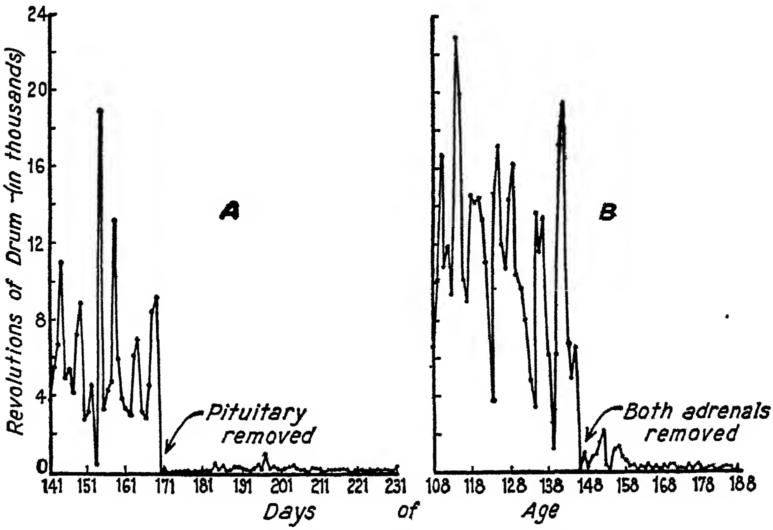


FIG 12—Activity and the endocrine glands. These curves show the sudden drop in the amount of general activity when the endocrine system is grossly interfered with In *A*, the effect of the removal of the pituitary on running activity, in *B*, the effect of removal of the adrenals From C P Richter, *Amer. J. Orthopsychiat*, 1932, vol 2, p 347 By courtesy of the editor and the author

lating the organism Sometimes the glands lower the thresholds for so many different muscular responses that the animal shows a great deal of diffuse, restless, all-round activity. The glands keep the animal active. In numerous recent experiments, glands have been removed, with the result that the total amount of activity is greatly reduced Compare Fig 12. In some cases the effect of the endocrine glands is to lower thresholds *in general* so as to cause an increase in *all-round activity*; in other cases the effect is limited and *specific*. We noted above how substances in

the blood of a hungry animal cause specific contractions in the stomach to appear Sexual and maternal behavior is also found to be not so much a matter of general diffuse activity as of lowering the thresholds for specific activities, those involved in courtship, mating, nursing, etc. Probably every endocrine gland affects general activity or restlessness to some degree, but also has some specialized function, acting on some reflex pathways more than it does on others. It will be worth while to sketch briefly here the rôle of the endocrine glands in relation to motivation

One gland about which a good deal is known is the thyroid. This is in the neck, and has one lobe on either side of the windpipe, and a strand running across connecting the two. This gland manufactures thyroxin, a substance rich in iodine. The iodine, of course, has to be taken in with the food, and it is the business of the thyroid to utilize this in the making of thyroxin. The failure to take in enough iodine in the food puts a strain on the thyroid, and the gland sometimes enlarges in such a way as to form one of the many kinds of goiter. This is common, especially among women, in those parts of the world in which the water is deficient in iodine, for example, in the southern Alps and around the Great Lakes in the United States. Some cities now put a small quantity of iodine in the water supply

Among the more extreme physical manifestations of thyroid defect we find the "cretins," who, if not cared for medically, do not grow mentally beyond the level of an average child of four or five years.

The influence of the thyroid upon the emotional make-up is equally striking. Cretins are usually slow, unexcitable, torpid Among otherwise normal adults in whom the thyroid has for some reason ceased to do its work adequately, the same lack of energy often appears. On the other hand, too much thyroid secretion is often attended by agitation, excitement, apprehensiveness—a state directly opposed to that appearing when the thyroid is under-active.

Noting such effects as these, some writers have hastened to conclude that emotional traits, and even personality as a whole,

must be entirely determined and controlled by the glands of internal secretion. This view is almost certainly false. For one thing, though we grant that there is often a relation between emotional traits and glandular make-up, it seems that in some cases the emotional characteristics help to determine the glandular functions; in fact, there is usually a circular relation between emotional traits and glandular functions.

Along with the thyroid, we must consider the parathyroids, little glands near the thyroid which play an important part in the body's use of calcium. The parathyroids seem connected with emotional stability. Some people suffering from a defect in the parathyroids are restless and agitated to an extreme degree, cannot keep their attention on anything, and show the greatest difficulty in trying to do any kind of consecutive mental work (for example, taking an intelligence test). Here, again, the extremists have done harm by implying that all emotional instability is of glandular origin Probably only a small percentage has any clear relation to glandular defect.

The sex glands, or "gonads," have been studied with fair thoroughness. As a result of careful animal experimentation, there is at hand a good deal of precise information which throws some light upon medical findings in human subjects There is no doubt that human sex development, both physically and psychologically, is dependent to a considerable extent on normal gonad functioning, and that both exaggerated and defective functioning of the gonads may result in serious social, as well as sexual, maladjustment. Several other glands, however, cooperate in the process of guiding normal sexual growth; among these must be mentioned the pineal and pituitary, both inside the skull.

With proper experimental conditions, the gonads may be removed and transplanted in another animal of the same or opposite sex Sudden, prompt, and specific changes in behavior are thus induced in the second animal. It is even possible to induce the characteristic male or female behavior in an animal thus treated, as if the animal had been born a member of the opposite sex

In some cases this detailed experimentation is not required to bring out clearly the functional significance of the glands, for the maturing of the glands occurs at almost exactly the same age in all members of a species and produces a sudden and complete change in their pattern of response

Glands do not function in isolation; they interact There are many interesting cases in which glands work like a cooperating team, and again cases in which they stand in opposition or balance. One case is the balance between the gonads and the thymus gland, which is near the thyroid The thymus, or "gland of childhood," plays an important part in normal growth before puberty. During the "teens" in our climate and under our conditions of diet, etc, the thymus is undergoing "atrophy" This seems to be a direct cause of the rapid increase in gonad function; in fact, too early or too late an atrophy of the thymus may cause a premature or delayed adolescence. The point is of some interest in relation to racial differences. There is, of course, a difference in the age, and consequently in many details, of the onset of puberty, even within various subdivisions of the white race; and some of the recognized physical differences between, let us say, Swedish and Italian individuals *may* have their origin in different glandular make-up Of course, before we can really decide about this, we shall have to know a great deal more about the influences of different climates, diet, etc, on the glands

We shall discuss the operation of the adrenal glands in considerable detail in the following chapter in relation to the arousal of strong emotions (page 74).

Since the chemical effects of the endocrine glands, and indeed all the effects of body chemistry, relate to the *whole* body rather than to specific parts of it, one would expect *general* aspects of behavior to be affected more often than specific ones One might expect, for example, to find at times some relation between a person's amount of energy and the amount of some substances in his blood; but one would not expect a *specific* habit, such as boasting or punctuality, to bear a close relation to general body chemistry. Specific habits like these call for specific rather than

general explanations, and we shall consider later the way in which such specific personality traits arise.

Motives set going preparatory responses and consummatory responses.—We have analyzed motives in relation to the physical changes in the body which arouse them. We must next describe the kinds of activities which appear when a drive is aroused It is important to distinguish between those responses which bring the organism into relation with the stimulus—these are called *preparatory* responses—and another group of responses in which there is direct interaction between the organism and the stimulus—these are called *consummatory* responses. The preparatory responses are aroused when a drive is at work inside the body, but no stimulus is present which is directly capable of putting an end to the drive. The consummatory response is one in which the body acts upon the stimulus itself in such a way that the drive is satisfied and the activities which have been aroused come to an end The distinction is brought out in the case of salivation and digestion The flow of saliva is a preparatory response aroused when hunger is keen Digestion, on the other hand, is a consummatory response, the food is assimilated and the restlessness of the animal disappears as a result of the satisfaction of the drive. By satisfying a drive we mean simply the removal of the source of unrest or tension in the body. In most cases where restlessness is due to a definite drive, it is easy to tell which act is the consummatory one by noting the promptness with which the restlessness subsides Many biologists believe that some preparatory responses and all consummatory responses are innate It is clear that some preparatory responses—like the salivation just mentioned—are provided by nature. And in general it is probable that most consummatory responses are provided for by nature. There are definite stimuli which act on the body and thereby set going the consummatory response.

Most preparatory responses are not specific except as a result of learning.—It is well to learn these points from the biologists, but it is important in the study of human nature to note the enormous degree to which the preparatory responses can

be changed by experience. Even the newborn calf or colt noses about and makes many vague movements before it finds out where and how to get its milk. Human infants are just as confused and show just as clearly the influence of practice, the gradual dropping out of irrelevant movements, the gradual learning of the right ones. There are many reasons to believe that human instincts in general, though based on reflex activities, are molded by experience to a large degree. The tragedy of sex perversions or misdirected maternal feelings shows how, under conditions of human civilization, not only preparatory but even consummatory responses may get attached to stimuli other than those which represent the best biological adaptation. Human instincts are always partly a matter of specific reflex acts and partly a matter of social experience or learning. And the importance of the learning process varies with the complexity of the act and the complexity of the social regulations governing it The preparatory responses are much more affected by learning than the consummatory ones are For example, we learn to eat with knife and fork; but the stomach does not have to learn to digest.

Some motives, such as curiosity, seem to depend upon the brain rather than upon the rhythmic activity of the vital organs.—Many of the drives described so far are *chemical.* They relate to the need of the body for certain substances, or to the activity of the body in response to substances secreted by the glands Some of the drives or motives, however, are based on other types of bodily change. Some drives, such as fear, rage and disgust, are quickly aroused by external stimuli such as loud sounds, quick movements, certain odors, electric shocks, etc, whereas the chemical changes in the body come later. The drive therefore cannot be considered a result of the chemical change. Such drives as fear and rage seem to be action-tendencies in the nervous system itself, directly aroused by conditions acting on the body and not necessarily dependent upon any rhythmic internal change. We shall consider these in the next chapter. It seems likely that there are also some drives which depend neither upon changes in the vital organs nor exclusively upon specific stimuli acting

from outside, but in part upon the dynamics of the brain itself For example, curiosity, which is one of the strongest motives in young children and in many of the higher animals, seems to depend much more upon the brain than upon the variations in activity of the vital organs. It is, to be sure, aroused by external stimuli, but it may be aroused by an almost infinite range of different things. It is not like the precise, well-defined reflex responses of sucking, swallowing, blinking, etc

Some other drives, dependent on brain activities, are recognizable. One illustration is the case of likes and dislikes for certain tastes, whether we are hungry or not Similarly, there seem to be drives leading us to avoidance of certain sounds and smells and leading us in the direction of others. A sweet tone and a scratchy tone, though neither one is very intense, bring two characteristically different responses. We are so made that we like some sounds, smells, and tastes, and dislike others. These are motivating factors which probably depend largely on the brain. In so far as a drive is defined in terms of an activity which is kept going by an internal need, even the *color-seeking* or *tone-seeking* activities of museum visitors and concert-goers have every right to be considered *drives*. These drives, even including the exploratory drive, are probably not in a strict sense rhythmical, and in this respect they differ from most of the physiological drives. They might be called "brain drives."

There have been many attempts in recent years to make up *catalogues* of human motives or instincts. Some authors have suggested very few, others very many, true fundamental motives in human nature Some regard gregariousness, the tendency of people to associate together, as instinctive; others regard it simply as a habit. Even the curiosity motive, which we mentioned above, is not accepted by all psychologists as a true and dependable motive based upon the fundamental inherited make-up of individuals, they consider it rather as a result of learning under special social conditions. The following drives seem to represent a sort of *minimum* list in the case of most of the higher animals, since the

physiological basis for them is fairly well known and they have proved relatively easy to study: hunger, thirst, sex behavior maternal behavior, rest, and sleep We might include such simple things as breathing and the capacity to maintain the body temperature. It is clear that there is no sharp separation between the rather complicated motives like maternal behavior, and such simple reflex ones as gasping for air and swallowing food It is clear, in fact, that most of the basic motives which have just been listed involve both *visceral changes* and *groups of reflexes* which are governed by these visceral changes. On the other hand, the motives also shade off into quite complicated types of response such as the sheer love of muscular activity for its own sake, the desire to manipulate the world and be stimulated by it in all sorts of ways Most intelligent animals spend a large part of their time in "playing," and show rather little of the specific and narrow drive sort of behavior except when their physical needs are acute. Monkeys and apes are not governed most of the time by a narrow set of specific physiological urges Their life is more variegated, their activities more numerous, their goals more complex or less narrowly defined Little children spend most of their time playing at things which are far indeed from satisfying supposed "basic" needs. We find, when they are interested in their games, that it is often as hard to make them eat as to make them go to bed

If this is true of children, it is doubly true of adults who have discovered a far wider range of interests and activities The simpler motives are a good starting point, but it would be foolhardy to maintain that our interest in music is reducible to the biological utility of using our ears or that our interest in botany or chess is solely due to the fact that we were taught by our parents to be interested in these things The sheer fact of having a brain makes it fun to use it. Though the simpler visceral drives may play a part in all these more complicated things, it seems likely that the brain itself is a basis for some of our most profoundly motivated activity. It would not only be foolish to tell

where the visceral factors stop and where the intellectual factors begin; the probability is that our more complicated social interests and activities, like talking, singing, dancing, swimming, or planning a vacation, are the product of many motives acting at once, each of these motives depending upon the vital organs to some extent and also to some extent upon the brain. The love of athletics and the love of travel are examples of complicated motives involving broad general "drives" which have been given specific form by the particular civilization in which we grow up. All races of men love athletic sports and journeys; but their specific tastes reflect their own *social habits*. Human life is full of broad drives of this sort dependent on both innate needs and social experiences.

Making up a list of all the human instincts or motives is not therefore a very profitable enterprise, unless one wishes to restrict the term motive simply to the visceral factors. If one bars the simple reflexes on the one hand and all the more complicated social motives depending upon the brain on the other hand, he will find left only a few visceral rhythms and not much else. Nevertheless, there is reason to believe that some of these complicated motives are just as important as any of the simpler ones. Consider the tremendous importance in social life of the *prestige motive*, i.e., vanity, or the thirst for recognition or the good opinion of our fellows. Many a battle for money is really a battle for power, and many a battle for power turns out to be really a battle for a place in the sun, an enviable position in the eyes of other men There are many possible interpretations of this motive, of which four will be listed here, just to give the student a conception of the difficulty of tracing social motives to simple physiological origins

1. Vanity, or the desire for prestige, is an innate mode of response as fundamental as the exploratory tendency or the maternal drive.
2. There is an innate tendency to approve some of the acts of others and to disapprove other acts, and also a tendency to

be satisfied by approval and annoyed by the disapproval of others; four separate instincts are really involved.

3. Past satisfactions of all sorts have arisen in situations where we are approved, and distress where we have been disapproved. Approval and disapproval are responded to only because of past associations of agreeable or disagreeable sorts
4. The affection of a little child is directed toward all sorts of objects. As the child grows, pressure is put upon him to recognize his own individuality; he is held responsible for what he does. He learns the boundaries of his body and the distinction between self and not-self. The self means mostly his own body which he sees and feels; and this, as a source of satisfaction, becomes an object of affection. Vanity is, as popular language suggests, self-love.

Experimental evidence to make possible a decision among these various explanations is not at hand. The important thing for the student or even for the professional psychologist is not to make a cut-and-dried list of human motives, but to understand clearly the principles which govern the study of the simpler motives and to make the most of the exact experimental techniques which we have for the study of such motives As these motives shade off into the realm of more complex and less tangible modes of response to people about us, it is important to keep our bearings in terms of the physiological facts, using these facts as clues wherever we can but at the same time refraining from dogmatism regarding the basis of those motives about whose physiology we know very little Certainly man is far more plastic, more modifiable by environment than any other creature. He shares the simpler motives with his animal relatives, but many of his most important motives evidently depend upon the actual development of his brain and the way in which the simpler motives have been modified and complicated by the social training he has received

Motives are powerfully influenced by experience and training.—It is well to warn the reader against thinking that human

motives frequently appear in pure form Most activity results from mixed motives. The motives are not only mixed by virtue of the fact that one stimulation brings out two or more motives at the same time; they are mixed by virtue of the fact that the motives are satisfied repeatedly in certain particular ways and not in others, so that a motive which was once *non-specific* becomes connected with *particular* kinds of stimuli. The child builds up, therefore, a *habitual* way of satisfying a motive Later on, new motives are aroused and connected with the object which has already proved so satisfying; additional motives get hooked up to these. A man who has a splendid collection of Chinese paintings has built up, in connection with this hobby, all sorts of satisfactions, personal and social, æsthetic and intellectual. The pictures mean so much to him that almost no aspect of his life is untouched by this special craving. Human motivation is infinitely complex. Its web is of a delicate, intricate pattern The study of the elementary forms of motivation is important, but equally important in the understanding of human motivation is the recognition of the diversity, richness, and many-sidedness of the motives as they express themselves day by day.

SUMMARY

In explaining behavior, the inner stimulation arising from motives is just as important as external stimuli are. The simpler motives such as hunger, thirst and the sex motive depend largely upon the activity of the vital organs including the glands of internal secretion. In human beings these motives are, however, greatly affected by social influences. In addition, there are motives which depend chiefly on the brain. These "brain drives" include curiosity, the desire for color and tone, etc, which result in behavior less narrow and specific than that which depends chiefly on the vital organs. Because of his capacity to learn, man's motives are greatly modified as the result of his experience, and they become woven into systems of habits.

REFERENCES

Allport, F. H, *Social Psychology,* 1924, Chapter III
Bernard, L L, *Instinct,* 1924.
McDougall, W, *Outline of Psychology,* 1923, Chapters III-V.
Murchison, C. (Ed), *Handbook of General Experimental Psychology,* 1934, Chapter I, by W. J Crozier and H Hoagland, and Chapter V, by W. B Cannon.
Tolman, E C, *Purposive Behavior in Animals and Man,* 1932
Valentine, W L., *Readings in Experimental Psychology,* 1931, pp 77-137.
Woodworth, R. S, *Dynamic Psychology,* 1918, Chapters I-IV.

PROBLEMS

1. What difficulties arise when we try to explain social behavior in terms of simple, specific motives? For example
   (a) "There will always be wars because men are naturally pugnacious"
   (b) "Politics must be corrupt because it is human nature to look out for one's own welfare first"
   (c) "Beethoven had to compose music because the musical instinct dominated him"
2. Is it likely or unlikely that all human beings are born with the same motives? Is it likely or unlikely that the relative *strength* of these motives depends partly on heredity? Cite your reasons
3. What is the difference between (a) a psychological, (b) a medical, and (c) an ethical study of motives?
4. What major differences are there between the significance of hunger in the total life of the rat and its significance in the total life of human beings in a complicated civilization? What reservations should these differences impose upon the analogies we may be entitled to draw regarding the motivation of rats as compared with that of human beings?
5. Answer the same question in relation to the sex and maternal drives in rats as compared with human beings.
6. Do you think the large amount of verbal elaboration of the sex and maternal drives characteristic of civilized society tends on the whole to intensify or to dilute the strength of these motives in the total pattern of life?
7. Can you think of any ways in which the relative power of different major drives could be measured in human beings?
8. What relation do all the various motives, such as money, power, learning, etc, which are so important in the lives of most people, bear to the "simpler motives" discussed in this chapter?

CHAPTER V

EMOTIONS AND FEELINGS

EMOTIONS

BEFORE concluding our discussion of the simpler motives, we found ourselves running into such terms as "fear," "anger," and the like—terms obviously pointing not in the direction of a specific need, but rather in the direction of a disturbance suddenly imposed upon us. Emotions, as distinguished from motives, can be differentiated in terms of this upheaval Here again, the psychologist has concentrated effort on the simpler emotions, a problem for experimental analysis The work of describing the more complicated emotional experiences he has left for the most part to novelists, dramatists, and poets; not that he is less interested in these, but he feels he must approach them slowly, through experimenting first upon simpler sorts of emotion.

Fear, rage, and intense pain throw the organism into a struggling condition.—All situations may be classified as normal and emergency situations, or as peaceful and warlike situations The normal and peaceful situations give rise to such functions as breathing, circulating, secreting, digesting, and so on The "simpler motives" which we have described come under this head In contrast with these are those situations in which the organism must struggle in a relatively vigorous or even violent reaction to the environment It is this group which will concern us chiefly in the present chapter Though a great range of such violent responses might be listed, we may for convenience classify these as involving fear, rage, and intense pain. Under experimental conditions the body seems to show about the same kind of response in these three conditions. There are all degrees of fear, rage, and

pain, but the general nature of the response is in many ways very similar.

A cat is comfortably digesting its meal (X-rays of stomach show the regularity of the digestive movements). A barking dog is brought near The casual observer sees only that the cat jumps up, arches its back, and spits or snarls. The physiologist sees a great deal more First of all, he sees (in his X-ray plates and other objective indications) the sudden stopping of the digestive movements. Second, his blood-pressure records show that the blood is being forced out from the trunk into the limbs, the blood pressure in the main arteries of the limbs being greatly increased above normal. Third, he notes a number of important changes in secretions, such as increased perspiration and decreased flow of saliva.

The struggle depends physiologically upon the positive activity of the sympathetic system and the checking of the activity of the cranial and sacral systems.—He finds that these changes in the body require closer analysis He notes changes in the activity of the *unstriped muscles* (cf. page 32), such as the iris of the eye and the little muscles which raise the hairs. These muscles belong to the same general system as the muscles of the digestive tract and the muscles in the walls of the arteries. The reader will recall that these unstriped muscles are not like the striped muscles of the arms and legs. On the contrary, they are parts of the primitive muscular system which in the course of evolution developed before the striped muscles and have to do with basic adjustments to disturbances caused by the outside world. In general, all these inner adjustments made by the unstriped muscles, which we shall find to be so important in the study of emotion, are controlled by the sympathetic division of the autonomic nervous system. This is shown in red in Fig. 13.

The reader will note that from the central nervous system shown at the left in black, there are nerves going out to the vital organs. These may be grouped in three main classes. The cranial system is shown in blue at the top. It goes out from the brain stem, and serves to control the muscles of the iris, the blood vessels to

various parts of the head, the salivary glands, the tear glands and many other small organs. This cranial system also sends fibers down to the heart, larynx, stomach, small intestine and many other organs, some of which are shown in the figure. At the bottom of the figure is shown, also in blue, the sacral division of the autonomic nervous system and the organs controlled by it. The cranial and sacral systems usually work harmoniously together in partnership. They are, for example, working together in controlling normal digestive activities. They are the chief physiological basis for the quiet, smooth-running activities which we described above as responses to "peaceful situations"; the cranial and sacral systems are therefore in contrast to all nerve fibers which are involved in violent struggle.

The middle division of the autonomic system, the *sympathetic* division shown in red in the figure, is the chief agency by which the *struggling* activities are controlled. The "red" stands in opposition to the "blue" in the sense that the two have opposite effects upon the same organs Just as the cranial nerves, for example, tend to hold the pulse rate down, so the sympathetic system tends to push it up, and the actual control over the heart depends upon the balance existing between the two If the cranial division is cut, the sympathetic division may be able, when acting alone, to push the pulse up to 300. If the sympathetic nerve fibers to the heart are destroyed, the cranial system may be able to push the pulse down to as low as 30. The ordinary increase from about 70 beats per minute to 150 or more when we become angry, frightened, or upset is chiefly the result of a change in the balance between the two, the sympathetic system being much more active in these violent or struggling states

The reader will note that practically all the vital organs are controlled by both the sympathetic fibers and the fibers of the cranial and sacral systems. If one knows whether a given activity is a peaceful or a struggling activity, he can usually tell without further discussion whether it will aid or hinder a given organ in doing its work For example, digestion is known to be a peaceful activity; it will therefore be evident that the "blue" cranial fibers

have a positive effect and that the "red" sympathetic fibers have a hindering effect or may even stop digestion altogether.

The present discussion refers of course entirely to *consummatory activities*. An animal may have to struggle in order to kill its prey The *preparatory* activities necessary before digestion can occur may not be peaceful at all. The consummatory acts of digestion, however, stand in such sharp opposition to struggle that, as we have seen, the digestive acts are stopped if the animal must recommence struggling. That sexual and maternal interests may be blocked by fear and rage is, of course, a commonplace in the observation of human nature; many other illustrations will occur to the reader.

In fear, rage, and intense pain, the sympathetic system is aided by the adrenal glands.—The sympathetic division of the autonomic nervous system not only acts to speed the pulse, increase the blood pressure, and alter the tension of unstriped muscles, it also has a number of indirect effects by way of the glands of internal secretion. Some of these glands have already been described (page 58), but we postponed the discussion of the adrenal glands because they are of very special importance in connection with our present problem, namely, the bodily condition during violent emotions. One of the most striking of all effects exercised by the sympathetic system is the stimulation of the adrenal glands. Fig 13 shows how these are controlled. It will be noted that they are under the domination of the sympathetic nervous system and that they are not subject to any control whatever from the cranial or sacral systems (no "blue" fibers lead to them) This in itself should make us suspect that they are connected directly with struggling activities. Under ordinary life conditions these glands are at work manufacturing and secreting small quantities of a substance called adrenin or adrenalin In times of stress the sympathetic system makes them do emergency work, resulting in a great increase in the amount of adrenin in the blood stream. The result is to help along the changes which have already been set going by the sympathetic system itself—rise of pulse rate, blood pressure, etc. Another effect is the liberation

from the liver of substances which increase the amount of sugar available as fuel in the blood. This fuel supplies energy to the striped muscles The chemical change in the blood also makes it clot more readily when exposed to air Most of these changes are obviously helpful to a struggling animal, that is, an animal fighting for its existence—whether it is struggling defensively against an enemy, or aggressively for its prey or for victory over other animals which compete for the food supply or some other need. All this complicated physical mechanism has been developed in relation to the needs of animals which have to be able to mobilize energy quickly and put up a vigorous struggle. This does not mean that nature has provided perfect adaptations to all possible situations, but in the long run animals equipped with these nerve fibers and glands are able to struggle, fight, defend themselves and run away, with a degree of success not attained by animals which are not so equipped Experimental removal of one of the adrenal glands results in a great reduction in the length of time during which an animal can put up such a struggle As we pointed out in Chapter II, behavior which is well adapted in one situation may not work well in another. Civilized man, to whom violent struggle is often an annoyance rather than a help, who loses his temper or becomes frightened in such a way as to interfere with the carrying out of a skilled act which might save his life, may suffer severely from the primitiveness of his whole autonomic nervous system. Not only excessive increase in blood pressure but even the complete stopping of digestion may result from the irritations and frictions of a business day The way in which necessary internal activities may be profoundly altered by violent emotion is suggested in Fig 14, in which it is apparent that adrenin in the blood interfered greatly with digestive movements. Similarly, fear in human beings may quite literally make them sick, and the whole body may become ill as a result of emotions which at a more primitive, uncivilized level would be of real service to the organism.

When the balance of the body is disturbed, it is usually restored within a few minutes; but sometimes an emotional tension in-

volving prolonged activity of the sympathetic system may continue for hours. There is no sharp line between the normal and the abnormal, and we may all at times remain frightened or enraged

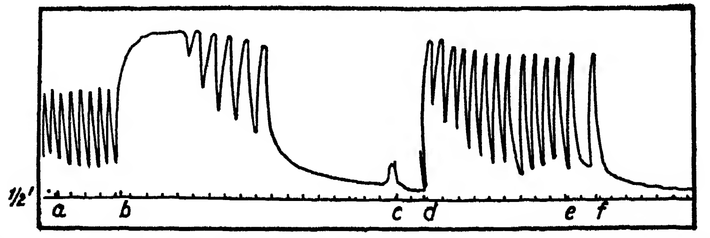


FIG. 14—Secretions from the adrenals interfering with digestive activity Intestinal muscle was kept in a salt solution and continued its rhythmic contractions (By means of a smoked-drum arrangement, a record was made of its activity For a typical smoked-drum arrangement, see Fig 25 (page 108) The drum is a metal cylinder about which a sheet of smoked paper has been fastened The cylinder is run by clockwork and revolves at a fairly uniform rate of speed If a pointer is set against the drum as the cylinder revolves, a white tracing will mark the position of the pointer If the pointer is connected by an air-tight system to something that we want to study, we can so arrange it that movement in our object of study will produce a corresponding movement of the pointer so as to give a record on the drum. After the drum has completed a revolution, the paper may be taken off and coated with shellac This makes the record permanent and measurements can then be taken from the paper. It is often desirable to have a time record right on the drum so that time intervals can also be directly measured. This is necessary because the drum may be made to go fast or slow. Ordinary drum records show a black background with a white tracing on it Here the record has been copied off and appears black on a white background The records are generally read from left to right)

In this figure, the effect of adrenal secretion on digestive activity can be seen by noting the stopping of the contractions of the intestinal muscle when "excited" blood, from a cat which had been barked at by a dog, was applied to the muscle At *a* the solution in which the muscle had been beating was removed, at *b* "excited" blood, i e, blood containing adrenin, was added, at *c* "excited" blood was removed; at *d* "quiet" blood, not containing adrenin, was added in its place, at *e* "quiet" blood was removed, and at *f* "excited" blood was again applied The time record is on the bottom horizontal line, each short stroke represents a half-minute From W B. Cannon, *Bodily Changes in Pain, Hunger, Fear, and Rage,* 2nd ed., D. Appleton-Century, p 51 By courtesy of the publishers and the author.

for such a long period as to upset the whole bodily machinery If this is carried to an extreme so that the person is under a chronic tension, we are dealing with a "nervous" patient. The physician can directly observe the activity of the unstriped muscles of the digestive tract by means of an instrument called a fluoroscope, and he may find repeated violent upheavals during the course of the

day which serve in part to explain the physical disturbances which accompany this mental condition.

This account of the experiments conducted by Cannon and others has aimed to describe the bodily changes during certain emotional states, but it does not tell us the relation between these bodily changes and the emotion as we experience it. Some psychologists prefer to avoid the question as to why we feel as we do in different emotional states, but others are greatly interested in the problem.

James and Lange suggest that emotions are experiences directly resulting from bodily changes, especially those in the vital organs and striped muscles.—Most of the discussion of what emotion really is, and how it is related to the body, has centered in a theory put forward fifty years ago by William James and C. G. Lange, commonly known as the James-Lange theory. Though they disagreed in details, they suggested independently that emotion as we experience it is simply our experience of the activities of the vital organs and muscles We feel the heart beat, the sinking sensation in the stomach, the trembling of the limbs, the parching of the throat. If we could describe faithfully how we feel as a direct result of a pounding heart, dry throat, flushed face, tense muscles, etc., the total result would simply be a description of the emotion. There would be no emotion above and beyond the awareness of these physical changes *If we could subtract from the emotion of fear all the tensions, tremors, chills, every other bodily sensation coming from the vital organs and muscles, we should have nothing left whatever.* Popular speech would say, "We see a bear, are afraid, and run." William James said, on the contrary, that we see the bear, run, and are afraid; the fear arises in consciousness as a result of the bodily changes which have followed upon our seeing the bear. We ordinarily say that we lose our fortune, are sorry, and weep James maintained that we lose our fortune, weep, and are sorry. Emotion is the kind of experience which arises from the activity of our vital organs and muscles

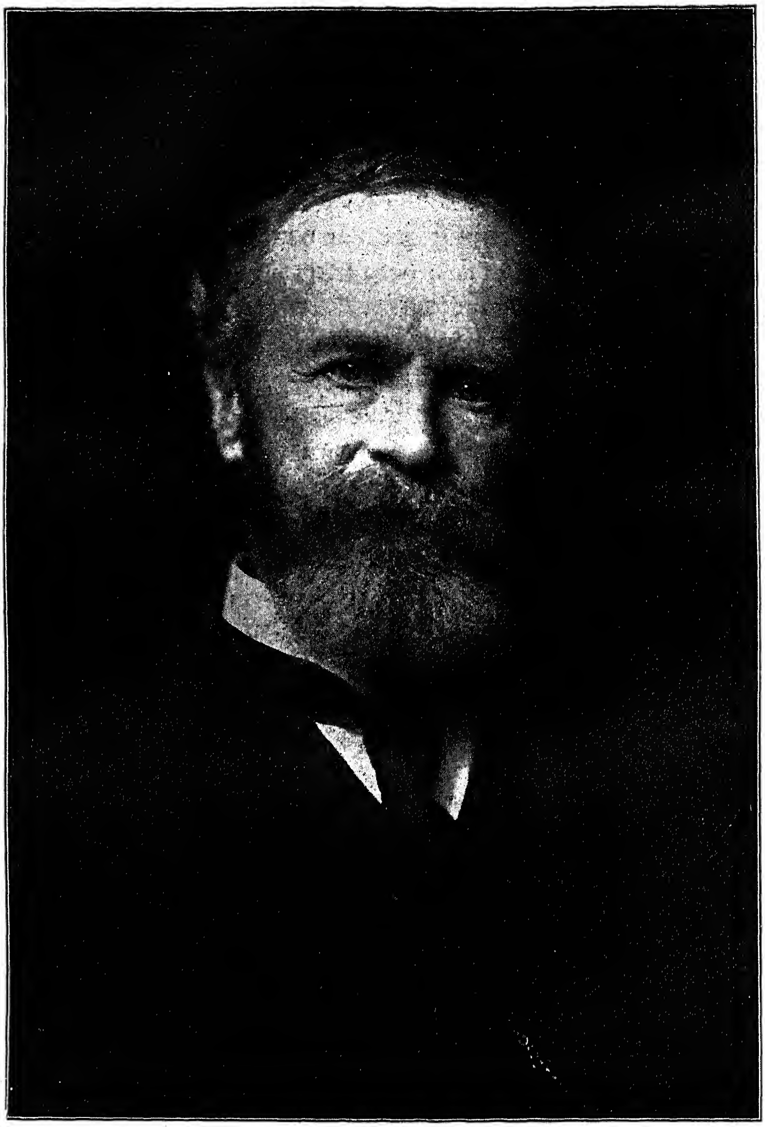


FIG. 15.—William James. Photograph through courtesy of James McKeen Cattell.

after we have perceived something. Diagrammatically, popular thought says:

perception ——————→ emotion ——————→ bodily response.

The James-Lange theory says:

perception ——————→ bodily response ——————→ emotion.

Objections to this theory are sometimes raised in some such way as this: If, when a man sees a bear, he is so frightened that he cannot run, he could have no sensation of running. This paralysis makes his terror that much the greater; when he is "cornered" so that he cannot run, the situation is worst of all. How can the emotion depend upon the response if the response does not occur? James retorts that the tensions in the muscles are very great even in these cases and that the disturbances within the body in the vital organs are even greater if the man cannot run. This seems to be a good answer.

Now as to the direct evidence for and against the theory: Ever since William James's time, physicians have made reports of individuals who are deprived of the normal sensations from the vital organs. If the theory is correct, we should expect a partial or complete annihilation of their emotions. A woman patient, for example, reported a complete loss of all emotion and when given a medical examination was found to be suffering from a general anæsthesia of the vital organs. No bodily sensations of the type which ordinarily underlie emotion could be experienced. On the whole, however, this line of verification has not proved very fruitful. The cases are too few, the testimony of the patients is not as a rule very clear, and the medical examinations are usually incomplete. In general, psychologists have therefore tried to solve the problem by well-planned experiments on animals, on which they can make certain crucial tests which cannot be made on human beings.

Experiments on animals show that the James-Lange theory does not cover all the facts.—Evidence from animal

experimentation seems to be pretty clear. Such experiments avail themselves of the fact that nerve paths from the vital organs are of two sorts: those passing directly up the cranial nerves to the lower part of the brain, and those passing first to the spinal cord and then onward by a second relay to the brain. Both of these nerve pathways were cut in a normal dog, supposedly depriving it of all ordinary visceral sensation from the trunk. Yet it continued to show just as much emotional response as ever. Whether the dog was still really angry or not could well be debated, but it barked just as violently as ever and behaved exactly like a very angry dog. An even more crucial test has recently been performed. When outgoing fibers to the viscera were cut (compare Fig 13), the sympathetic system being completely obliterated as far as its effects on the vital organs were concerned, emotion seemed to remain as powerful as ever. If there is no means by which the vital organs can be made to respond more vigorously in these times of stress, it seems a little far-fetched to suppose that the emotion depends in any way upon sensations received from these vital organs.

Another reason for doubting the James-Lange theory is that the three very different emotions of fear, rage and intense pain all seem to produce just about the same changes in the vital organs. If our awareness of these three depends upon the visceral changes, we should have to assume that it is hard to tell any difference between the experiences of fear, rage and intense pain. Yet there certainly are some occasions—bad toothache, for example—in which it does not seem at all hard to tell what we feel; and anyone who has been genuinely terrified, in a true panic of fear, is not very likely to confuse this with being in a "towering rage." This does not close the question, but it leaves the argument rather against the James-Lange explanation and necessitates looking more closely for a physiological explanation which will really cover the facts.

A center for emotion is found in the brain.—Direct study of the brain is probably a better approach. While most of the activities with which we are concerned in psychology depend

largely on the surface or "cortex" of the cerebral hemispheres of the brain, there are other parts of the brain which are important for the emotions. Emotions seem to continue even when the cortex is functioning only to a very small degree or not at all A "decerebrate" dog, one whose cerebral hemispheres have been cut away, will continue to whine and bark and bare his teeth. He is not so very different from a person just beginning to come out of ether, who may show an emotional outburst, an avalanche of violent and unreasonable response, which is quite astonishing. Such cases suggest that deeper down in the brain, below the level of the cerebral hemispheres, there is a region which is fundamental in relation to emotions. There is a good deal of medical evidence for this view. Changes in emotional make-up or in the whole personality may result from diseases in the lower part of the brain, known as the brain stem, for example, epidemic sleeping sickness (encephalitis lethargica). Certain parts of the brain stem, particularly a part called the thalamus, seem to be very important indeed in connection with our emotions. Patients who had suffered from a disease of the thalamus showed profound changes in feeling and emotion, or in *"affect"*—*"affect"* is a general term which includes the *whole feeling life*, pleasantness and unpleasantness, emotion, mood, etc. In these patients the sense-qualities—touch, temperature, etc.—were reported exactly as in normal persons, yet the *"affects"* associated with these sensations were out of all proportion to the intensity of stimulation. A slight tickling, for example, though perceived as mere tickling, became unbearably painful, and slight warmth which would ordinarily be slightly agreeable became very intensely agreeable. There was in general an *exaggerated affect*, though sensations were normal. In some cases the thalamus was diseased only on one side, with the result that stimuli on one side produced these exaggerated affects, but stimuli on the other side did not.

These facts have given support to the view that *the brain stem contains a center for the emotions.*

To test this theory, systematic animal experimentation has been

carried out, in which one part of the brain after another has been removed, beginning with the cerebral hemispheres and bit by bit working backwards and downwards. Compare Fig. 16. The removal of the cerebral hemispheres not only fails to deprive the animal of emotion; on the contrary, it seems to increase it But as experimenters work back from the very foremost part of the brain stem they find rather suddenly, upon reaching the area indicated by dots without cross-hatching in Fig. 16, that emotional disturbances cease to appear.

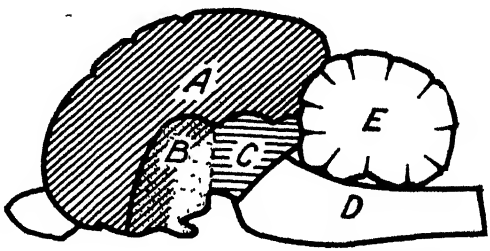


FIG 16—Section through the middle of a mammalian brain *A*, the cerebral hemispheres; *B*, the diencephalon, or between-brain (which includes the thalamus), *C*, the mesencephalon, or mid-brain, *D*, the medulla oblongata; *E*, the cerebellum *The light, dotted part of B is the center for the emotions* The cross-hatching from right downward to left, in *A* and *B*, marks the part of the brain which can be removed without interfering with the expression of rage Once the emotional center is cut into, however, emotional disturbances seem to disappear Modified from P Bard, in C Murchison (ed), *The Foundations of Experimental Psychology,* Clark University Press, p 472 By courtesy of the publishers

A rather small region seems therefore to be the seat of the emotions As long as this emotional center remains, stimuli which ordinarily arouse rage, such as interference with an animal's movements, continue to produce the same rage They may even produce an *increased* rage when the parts of the brain lying further forward are removed, provided this emotional center is not damaged. The exaggeration of the emotion in this case is attributed to the fact that emotion is characteristically *held in check* by the activities of the *cerebral hemispheres.* Cannon and his collaborators have definitely concluded that emotion is therefore a function of a particular part of the brain stem rather than an experience depending on the sensations from the vital organs and

muscles. This is called a "central" theory, as contrasted with a "peripheral" theory like the one offered by James and Lange.

Emotions seem to depend chiefly on the brain, but to be affected to some degree by the vital organs.—One may gratefully accept Cannon's work on the sympathetic nervous system without accepting his whole theory of the localization of emotions. The reader is urged to bear in mind that this is a complicated matter which is deliberately simplified here. Nevertheless, both aspects of Cannon's work have greatly enriched the psychology of the emotions and constitute an important chapter in the modern psychology of emotion. For example, though most of his work is on the emotion of *rage*, he has shown that it probably has significance for all emotional reactions

We have seen that adrenin is secreted more vigorously during times of intense physical stress and that it is important in the physiology of emotion. The question now arises whether the adrenin itself and the changes produced by it are important in relation to the emotional qualities of experience; whether, for example, the presence of an increased supply of adrenin in the blood really *causes a change* in the quality and intensity of emotion. To test this point, the commercial preparation "adrenalin" has been injected. Adrenalin produces in many subjects a feeling as if they were "going to have" an emotion; for example, a feeling as if about to weep or to be enraged. This has sometimes been called a "cold" emotion. In some subjects in a recent experiment no emotion of any sort resulted, while in others a full-fledged emotional experience was produced, even to the point of wanting an object upon which to express the emotion With eleven subjects and a total of twenty-two injections of adrenalin, "cold" emotions were produced in ten cases, no emotion in eight cases, pleasant emotion in one case, and unpleasant emotion in three cases. That the physiological changes resulting from the activity of the adrenal glands do actually play a part in emotion seems on the whole substantiated.

The following up of such evidence might even lead to a partial

confirmation of the James-Lange view. Organic change seems to contribute qualities of experience which in part determine the rise of emotion—at least in some cases.

Are there sharply distinguishable behavior patterns of fear, rage, pain, disgust, etc.?—Eighteen subjects took part in the following experiment: Each one was taken to the laboratory individually and asked to sit down in a chair (Fig 17) while the

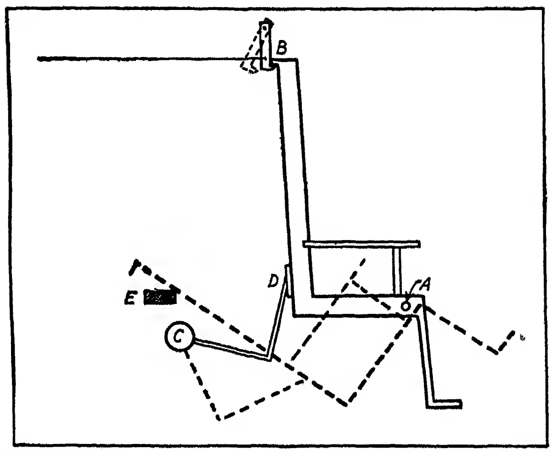


FIG 17.—Specially constructed chair to arouse fear in laboratory subjects. While the unsuspecting subject is sitting in the chair and different kinds of measurements are being taken, the hook at *B* is pulled back and the chair falls backwards until it takes the position shown by the dotted lines The subject is perfectly safe—*C* is a strong door check—yet characteristic fear responses are aroused. Modified from W. E. Blatz, *J. Exper. Psychol.*, 1925, vol. 8, p. 110. By courtesy of the editor and the author.

experimenter proceeded to prepare for observations on pulse, blood pressure, and so on Without any warning, the subject was thrown backwards in the chair sixty degrees, as the figure shows Since the subjects had been securely tied and the movement of the chair was gradually checked without a bad jolt, no physical harm was done, but the subjects were genuinely frightened. Records were made of the pulse, blood pressure and breathing, with the results as to pulse shown in Fig. 18. In the case of this first fall, there was a rapid acceleration of the pulse, followed by

a slowing down, a second acceleration and finally a gradual decline. The breathing rate for the first fall increased gradually for a minute, then declined. The respiratory index (the time spent in "breathing in" divided by the time spent in "breathing out") showed a large and steady increase for some six minutes. A

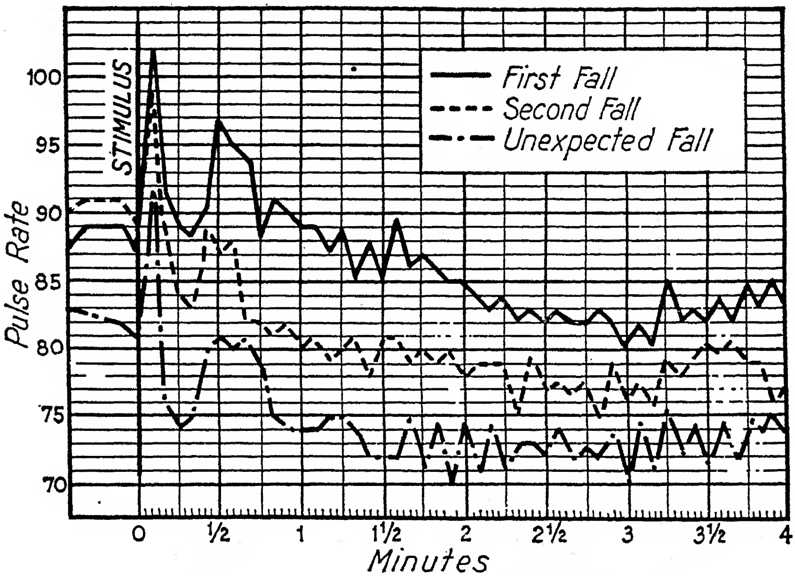


FIG. 18.—Changes in pulse due to the emotion aroused by the falling chair. The fall occurred at the zero on the base line, and pulse rate can be read for the next four minutes. Note the difference between the three curves. "First Fall" was completely unexpected while "Second Fall" was specifically anticipated. The "Unexpected Fall" was unexpected but the curve is from a group of subjects who had gone through a series of practice falls. The effect was apparently greatest when the fall was unexpected, though practice reduced the amount of the response to the situation. From W. E. Blatz, *J. Exper. Psychol.*, 1925, vol. 8, p. 121. By courtesy of the editor and the author.

similar effect was obtained when the subject fell a second time, despite the fact that he knew that no harm would come. Some of the subjects who had gone through a series of "practice" falls were used in a final control series, and records were taken while they sat undisturbed in the chair, and also after they were given an unexpected fall. The graph shows that despite the many falls

which had preceded, the results in the case of pulse rate are fairly similar to those obtained previously

Change in pulse thus showed a definite fear pattern. These physiological changes follow a definite course which is similar from one subject to another; there are also fairly consistent changes in blood pressure. Fear is therefore not to be regarded as merely a subjective state. There seems to be a fairly uniform and definite physiological pattern.

Yet the experiment just described did not compare these fear responses with responses occurring in other terrifying situations, or with responses during anger or intense pain. The physiological responses reported by Cannon (pages 72-77) in relation to fear, rage and pain are all very similar. In the present case we wish to know whether this particular fear experience produced a unique pattern which *only this particular fear* could arouse, or whether it produced a typical fear pattern which *all* fear situations of all possible kinds might produce. Cannon might very well say that the fear pattern just described is simply a general pattern for all violent emotion of the kinds upon which he has conducted research, and that similar patterns would have been aroused by abusive insults or other sudden rage-producing stimuli, or even by sudden and intense pain *Can the different emotions actually be distinguished from one another?* We are not speaking of the difference in our own personal experience between fear, rage, and pain, we are concerned with differences *in behavior* which can be recognized. Our problem resolves itself into three questions: (1) Are we born with distinct patterns of emotional behavior? Is it simply human nature to show fear, rage and pain responses which are clearly distinguished from one another in such a way that the observer can tell which is which when observing a newborn child? (2) If infants do not show patterns of this sort, do adults show such emotional patterns? (3) If there are any differences between the emotional patterns which we show at birth and those which we show as adults, how do these changes come about?

In newborn infants such emotional patterns are still very indistinct.—The infant at time of birth has undergone a proc-

ess of specialization within his nervous system, as already described on page 40. Instead of merely mass responses, he shows a number of reasonably precise reflex responses to particular stimuli Tickling the sole of the foot causes characteristic movements of the toes Pinching one knee sometimes brings out the "protective" movement of the other leg which kicks away the offending hand. Inserting a pencil in the baby's hand can be counted upon to produce a clasping movement and a fairly strong grip so that most babies can be lifted to support most or all of their weight. Almost every one of the infants tested at the Johns Hopkins Hospital could hang on for a number of seconds to a pencil which was gradually raised The contractions of the pupil of the eye, the sucking and swallowing movements, and perhaps twenty other responses are ready for action at or shortly after birth. The question now arises whether over and above these specific reflexes the specialization of the nervous system has produced, by maturation, recognizable patterns of fear, rage, pain (and perhaps other forms of emotion or excitement) which can be called out by definite stimuli of various sorts There is a considerable amount of experimental work on this problem which we shall now analyze.

Though there are many simple reflexes present at birth, these are not organized into definite groups or patterns, each sharply distinguished from the others. J. B. Watson found that by striking a metal bar producing a loud clang, it was possible to bring about in practically all infants a response which he called "fear." A somewhat similar response was aroused by letting the baby drop from one person's arms into those of another, by tugging at the corner of his blanket as he lay asleep, by immersing him in a tub of water—in fact, by a considerable range of disturbing stimuli Nearly all normal babies are upset by these situations. They tend to clasp, to clutch, to struggle or to draw back. Watson did not say that the fear response to the loud sound was *identical* with the fear response to the loss of support, but he did insist on a certain general resemblance. There is a large amount of general slashing and kicking, crying and trembling, common to all these

responses. Watson found, in contrast to the fear response, a rather well-defined rage response shown in a characteristic cry, a catching of the breath, struggling, stiffening of the body, thrashing of the arms, and kicking—for the most part, movements aroused by something which restrained the infant's free use of his limbs Even the use of cotton pads to hold the baby's head, when testing him for eye coordination, produced rage; this came out in extreme form if the baby's arms were held. Certainly Watson seems to have some grounds for saying that fear and rage, even at birth, show some sharp differences. The amount of muscular cramping and the way in which the breath is caught during the struggling activities seem to differentiate clearly the patterns of fear and rage, and there certainly seems to be a distinction between the plaintive cry which we classify as fear and the cry of protest which we connect with anger. Differences between these kinds of cry have recently been carefully studied by means of electrical recording of the sound; the experimenters seem sure that these cries can be recognized by examining the electrical record. One has to know what to observe; but in everyday life much is confused. Even well-trained observers have been found to be confused in attempts to tell whether a given response is fear or rage. Observers who are less well-trained may do scarcely better than what others would achieve by sheer chance. Sherman found that nurses watching motion pictures of the rage behavior of infants and not knowing what had caused this behavior, called it "colic," while a number of medical students, also without knowledge of the cause of the trouble, thought that the infants were suffering from "organic brain disease." If we talk of a distinct pattern of fear response and an equally distinct pattern of rage response, we shall have to admit that there are many common elements in the two patterns, elements which no one can clearly assign to the one or the other The total response patterns of rage and fear may be said to overlap a good deal. In the same way rage and pain, or even fear and disgust, may be said to have something in common There is a general upset condition which makes up a prominent part of all these patterns in the behavior of small infants. In other words, the

emotional patterns are not very sharply distinct at the beginning of life.

As the child grows, the different emotional patterns appear.—Despite all this, there seems to be gradual differentiation of responses going on month by month. F. L. Goodenough has found that unposed pictures of a ten-months-old girl could be properly classified by graduate students in terms of the kinds of situation which would arouse the response shown in the photograph. It is hard to believe that the little girl had *learned* how to show fear, rage, disgust, etc., and that no clear-cut inherited patterns had appeared. Goodenough has also reported on a girl 10 years old who had completely lost the senses of sight and hearing in infancy and who certainly could not have learned the conventional social ways of expressing the various emotions. Yet this ten-year-old showed disgust, fear, pain, etc., in absolutely clear-cut patterns Goodenough thinks that the case is strong for believing that the different emotional patterns arise through maturation They differentiate gradually, step by step, from the original diffuse mass response which might be called "emotion in general." It is quite likely that this maturation process may go on for years. Of course social factors—learning how to express different emotions and how to inhibit others which are not socially approved—must be credited with a good deal, but it seems very improbable that these factors of social training could completely explain the development of characteristic patterns.

If this view is correct, more and more specialized patterns of response should appear from one level of development to the next The number of distinguishable emotional patterns may be very small in the newborn, yet there may be four or five patterns in the two-year-old child and ten or twenty in the four-year-old. Over and above the effects of maturation we must bear in mind the influence of our conventional ways of expressing emotion, whether at the dinner table or in the drawing room or even on the stage. For example, even if only five emotional patterns are inherited, these may be molded by social training so that we show fifty different refinements of expression. The fact that there are many

names for the various emotional states and that these terms are not always translatable from one language to another suggests that adult patterns are *many* and that they differ to some extent from one country to another

Even the most definite patterns in adults may be obscured under great tension.—A group of adult subjects was presented with a long series of emotion-rousing stimuli, some of which were intended to bring out laughter, others embarrassment, still others fear or distress Hour after hour the general emotional tension increased. Rest periods involving mental work were followed by new disturbances and shocks In this prolonged tension a sort of mass response or upheaval appeared in most subjects Detailed measurements were made, including a systematic study of photographs of the changes in facial expression as shown by burnt-cork tracings which marked out the different groups of muscles in the face One might think that the different emotions could be read off from these pictures—for example, that one could tell what emotion the subject felt at a given time or at least describe whether the subject liked the situation or not. Nevertheless, under these conditions the emotions were found not to be distinguishable from one another. There was no consistent external pattern of expression corresponding to any specific emotion or to any specific situation There was not even a characteristic happy expression and a characteristic pain or distress expression It must, of course, be remembered that the subjects were on the defensive against betraying their emotions (because it is "weak" to do so), particularly the wincing from pain or the direct revelation of their fear. Even so, it is surprising that different emotional patterns did not emerge.

It seems to the writer that the experiment tends to support the view that all emotions when they are intense resemble one another a good deal, at least in their physiological expression. Even though some of the stimuli were pleasant, what we get in these photographs indicates extreme anxiety or tension, and this tension is a good deal the same whether it is aroused by pain, fear, embarrassment or disgust. Even the pleasant stimuli did not have a

FIG. 19.—Broad jump.

chance to be disentangled from the rest, for the subject suffered cumulative effects from the long ordeal and expected new trouble at any moment. The most intense emotions are characteristically harder to distinguish than milder ones are. This experiment by Landis, though it seems very far from conclusive, does in some respects seem to show that the manifestations of

FIG. 20.—Enlarged from Fig. 19.

severe emotional upset are about the same, no matter what its cause.

We might hazard the statement that very intense emotion often gives about the same kind of expression, and that in this there is a great deal of tightening of the muscles of the face, hands and other parts of the body. This muscle tension is hard to pin down to one specific expressive pattern. Fig. 19, for example, shows a genuine, not a posed, expression. Cutting a hole in a piece of cardboard will make it possible to show the face without its sur-

roundings, a face which we should probably associate with fun and jollity rather than with intense and violent effort. Compare the enlargement in Fig. 20 and the variety of expression in Fig. 21. Obviously, Figs. 19 and 21 are not pictures of what we should ordinarily call emotion. They show simply intense effort. Nevertheless, if the background is removed they seem to be pictures of emotional expression. Intense emotion and intense effort come to the same thing as far as their objective manifestations are concerned

Despite large differences in expression from one person to another, it is likely that all emotional patterns are similar when they become sufficiently intense, and that the observable physiological state during intense pain, wild fury and an extremity of terror is all very much alike. It is only in the middle range of emotions that distinctive patterns can be recognized. Very intense emotions and very mild ones are much more difficult to discriminate than those of moderate strength. We venture the statement that emotional expression always includes a *general* aspect, together with a specific aspect In mild protest or fear the *general* aspect, consisting of a diffuse disturbance or upset condition, is more apparent than the specific aspect which is visible in the muscles of the face or in gesture and posture In the most extreme emotion, likewise, the general aspect may reach the extremes of emotional disorganization so that intense fear and intense anger or pain are indistinguishable. In the middle range, however, the general aspect or all-round disturbance is less prominent than the *specific* aspects which show themselves in specific reactions of face, hands, etc.—for example, the "attack pattern" of anger or the "escape pattern" of fear Furthermore, it is only in the middle range of emotional intensity that emotion seems to be biologically efficient Little emotion produces no action; too much emotion makes one impotent for action.

Emotion is *usually* a matter of coordination, not simply of chaos It is well to emphasize the chaotic aspect of a strong emotion, but it is equally important to emphasize the relatively well-organized expressive movements which occur in less extreme situa-

FIG. 21.—Ambiguity of facial expression. Looking at each face through a small circular hole in a piece of cardboard, can you see why one subject classified the faces (left to right) as expressive of "doubt," "agony," "amusement," "rage"? (© Acme.)

tions. The coordination involved in smiling and laughing is easy to bring out by controlled experiment, for example, by applying an electrical current to the nerve serving the muscles of the cheek. Fig 22a shows a smile arising from such stimulation If the same stimulation were given on both sides of the face we should have the result shown in Fig 22b Here, however, the reader will remember that smiling may very frequently occur in other con-

a b

FIG. 22.—Schematic view of one of the basic facial patterns which appear when experimenting with electrical stimulation of facial muscles. This shows the pattern when there is, in general, high muscle tonus In (a) the effect of electrically stimulating *one* cheek can be seen, (b) shows the theoretical effect of the same electrical stimulation to the two cheeks. Modified from G Dumas, *Traité de psychologie,* ii, p 630, F Alcan & Cie.

ditions than that of joy. The pattern of a smile seems fairly simple, yet there are different kinds of smiles which show themselves in different patterns of muscular contraction. These patterns we learn to pick out and respond to with reasonable efficiency. Again it is well to remind the reader that part of our skill in doing this, and probably *part* of the specific detail of the expression, is the result of *social training.* We have to learn how to interpret the expression of others, and how to modify our own expression.

To recapitulate, we would point out that specific emotional patterns are absent in little infants but that they are fairly clear among adults *if the emotion is not too intense.* The development of specific emotional patterns during childhood seems to be the result both of maturation and of the learning process in social situations. On the whole, maturation seems to explain the main outlines of the different expressive patterns, fear, rage, disgust, joy, etc. But social factors give richness and subtlety to all emotional expression.

FEELINGS

Feelings of pleasantness and unpleasantness may occur in emotional states but they may also occur independently. —In the excited states which we call emotions, various elements which are clearly distinguishable may be analyzed; a moment after a burst of temper has subsided, it is not hard to recognize a sense of tension in some of the muscles, the pounding of the heart, the moisture of the skin, the warmth of the face, and many internal processes (page 77). In addition to these sensations from the body, there are certain processes which can scarcely be called sensations in any ordinary use of the term These are *feelings of pleasantness and unpleasantness.* These feelings may occur also when no *emotion* is present—for example, in experiencing a pleasant taste, odor, or sound.

These feelings are usually not localized in space or "referred to" points in space as most sensations are. Feelings of pleasantness and unpleasantness may seem vaguely within the trunk or within the body as a whole Sometimes, as in intense joyful response to music or a landscape, they may seem to be "out there," wherever the stimulus is. Unpleasantness, as in the case of a dull ache or a throbbing pain, may seem to be wherever its cause is, as when the pain from a toothache may lead the observer to say that the unpleasantness is itself in the tooth; but it is characteristic of such feelings, especially if they become strong enough to provoke

real distress, to seem to fill the whole mouth, or the whole head, or the whole body, or even to spread out and make the whole world one big heap of misery. This tendency for pleasantness and unpleasantness to spread out and seem to belong to the objects which occasion them, has been much exploited by poets and essayists; and it plays a certain part in the "pathetic fallacy" to which we resort in referring to a "miserable little hut," a "cheerless desert," etc. The desert is probably not cheerless, but we are cheerless in it. Undoubtedly the reader can think of many other illustrations.

Effort has been made to find definite bodily changes which always accompany these feeling states; but no physiological changes have been found which always go with particular kinds of feeling states. Even the simple distinction between pleasant and unpleasant seems to permit of no simple definition in terms of heart action, breathing, etc Pleasant experiences sometimes send the pulse up, sometimes send it down, etc. The electrical changes in the body (cf. page 107) vary with intensity of feeling, but only very roughly, and it cannot even tell us whether a subject is experiencing pleasantness or unpleasantness.

There are far more instances of mild pleasures and mild "unpleasures" than there are instances of *intense* joy or intense distress Feelings can be arranged on a straight line from the intensest unpleasure to the intensest pleasure. Objections are therefore raised to the view that one could ever experience more than one feeling at a time. Furthermore, experimental evidence under the best-controlled laboratory conditions fails to demonstrate that subjects can actually experience both pleasure and unpleasure at the same instant. A tooth might be throbbing at the moment that good news was received—one must admit that the *stimuli* for both responses were simultaneous. Yet characteristically the feeling is either the alternation from unpleasure to pleasure, or a sort of fusion in which the good news produces for the moment a happiness somewhat less intense than that which would be experienced under ordinary conditions of no toothache.

These feelings depend on brain-stem activities.—Experimenters have studied the relation of these feelings to the centers in the brain stem which we have already described as the seat of the emotions, and have shown that the same center in the brain stem which underlies the expression of the emotions underlies also the experiences of pleasantness and unpleasantness. Persons suffering from disease in this part of the brain stem (cf. page 81) are upset by very slight stimuli—the scratching of the skin with a needle which would ordinarily produce slight unpleasantness produces excruciating pain; the hot water bottle which would ordinarily produce mild pleasantness produces very intense pleasure The exaggeration of these feelings was a uniform finding among such patients. Particularly striking is the fact that when the brain stem was injured on one side and not on the other side, stimulation of the brain stem produced exaggerated pleasantness or unpleasantness in one side but not in the other. It appears, therefore, that the center for the emotions is also the center for the feelings, and this justifies us in the conclusion that this experience which we call feeling is psychologically very close indeed to the experience of what we call emotion. It would probably be correct to say that simple feelings, such as those aroused by a cool breeze or a refreshing drink, and definite emotions, like fear and rage, are all controlled partly or completely by this brain-stem center.

This is all right as far as it goes, but we wish to know also what it is that ordinarily acts upon this center. Disorder of the brain-stem center is infrequent, but something in the body is almost constantly arousing feelings of pleasantness or unpleasantness in greater or less degree. What is the normal way of exciting this region? The answer lies in the fact that this central location is easily accessible to stimuli, and excitement is set up within it by a great variety of impulses coming from the striped and unstriped muscles and from the skin and vital organs. Most of the primitive satisfactions and annoyances of life, such as the pleasantness of a good meal and the unpleasantness of indigestion, are connected with this brain-stem center. Even complicated skilled

acts carried out by the striped muscles, which ordinarily are thought of as arousing no special feeling, do arouse some sort of feeling, depending on whether they are easily carried out or whether there is much interruption, confusion, or fatigue In general, those activities in the body which give rise to pleasantness are smoothly running, unchecked activities. Those which give rise to unpleasantness are blocked or inhibited activities. Few things are as annoying as interruption, few things as satisfying as the completion of a well-regulated, smoothly flowing muscular act in which no interference is presented Even such simple things as digestion and indigestion may be looked upon as completion and the failure of completion, respectively, in the carrying forward of a biological function. In the formation of every habit we pass from a stage in which there is a good deal of blunder and consequent annoyance to one in which the action is smooth and easy If we are highly skilled, the annoyance if we are interfered with is greater than it would be for the beginner. The skilled worker has built up a set of habits upon which he relies absolutely, so that the whole body is thrown into a certain rhythm; he is not prepared for a checking or interference. The beginner, on the other hand, is more or less prepared for failure at every point, and he is not blocked in such a sudden and complete way by the mere fact that he makes a mistake or that his activity is temporarily interrupted One of the most painful of all experiences is to be emotionally aroused in a particular direction—for example, ready to express anger—and then find that the whole thing must be completely blocked The result may be not only to block some aspects of the anger but to make the whole experience very much more unpleasant than it was before. We might say perhaps that most anger arises from the blocking of our activities, but that the worst distress of all comes when our angry response to this interference is itself in turn blocked by a recognition of the necessity of keeping calm.

On the whole, this theory fits with all that we know about the action of the emotion center in the brain stem. Perhaps the

smoothly running activities act upon the brain stem in one way, and the interrupted activities in another way. Under certain conditions, however, the brain-stem center may be *directly* acted upon by disease or by chemical or mechanical excitation, and in these cases pleasantness or unpleasantness may be aroused directly. Pleasantness and unpleasantness are ordinarily set going, so to speak, by virtue of a roundabout process: smoothly running activities or inhibited activities bring changes in the brain stem These changes give us experiences of pleasantness and unpleasantness. Sometimes, however, disturbances in the brain stem (by disease, etc.) may short-cut the process and produce these feelings whether the body is completing some activity or not, and irrespective of whether it is being interfered with or not. Pleasantness and unpleasantness might therefore arise sometimes without outside stimulation of the brain stem. Ordinarily, however, these brain-stem activities would result from bodily activities.

SUMMARY

In addition to motives, which impel to action, there are conditions of bodily upheaval or struggle which result when the organism is disturbed. These conditions are called emotions Physiologically the upheavals called fear and rage involve vigorous activity of the sympathetic division of the autonomic nervous system and the adrenal glands, and the checking of the cranial and sacral divisions. The different emotional patterns are not distinct in the little infant, but arise in childhood chiefly as the result of maturation. Probably every emotion may be said to depend on both (a) sensations from the vital organs and striped muscles, and (b) the activity of the brain stem; but the latter seems to be the more important. Feelings of pleasantness and unpleasantness are closely related to the emotions, though they may exist independently. Feelings of pleasantness and unpleasantness seem also to depend primarily on the activity of the brain stem Feelings and emotions together are called affects.

REFERENCES

Beebe-Center, J, *The Psychology of Pleasantness and Unpleasantness,* 1932

Cannon, W. B., *Bodily Changes in Pain, Hunger, Fear, and Rage* (2nd ed), 1929.

Dashiell, J. F, *Fundamentals of Objective Psychology,* 1928, pp. 205-227.

Garrett, H E, *Great Experiments in Psychology,* 1930, Chapters VII and X

James, W., *The Principles of Psychology,* or *Psychology: Briefer Course,* 1891.

Ladd, G T., and Woodworth, R. S., *Elements of Physiological Psychology,* 1911, Part II, Chapter VII

Murchison, C (Ed), *Handbook of General Experimental Psychology,* 1934, Chapter VI, by P. Bard, and Chapter VII, by C. Landis.

Reymert, M L. (Ed), *Feelings and Emotions·* The Wittenberg Symposium, 1928.

Valentine, W. L, *Readings in Experimental Psychology,* 1931, pp. 139-178

Warren, H. C, and Carmichael, L, *Elements of Human Psychology* (rev. ed), 1930, Chapter X.

Watson, J. B, *Psychology from the Standpoint of a Behaviorist* (3rd ed), 1929, Chapters V and VI

PROBLEMS

1 Read through Part I in McDougall's *Introduction to Social Psychology* and compare his analysis of the cognitive, affective and conative aspects of emotion with the conception of emotion given here

2 Keep a record for two days of your own emotions, recording in each case general aspects of your physiological condition as affected by fatigue, sleep, diet, etc ; the situation in which the emotions occurred (people present, place, time, etc) ; the apparent cause of the emotion, a description of the emotion experienced and of its expression.

At the end of this period estimate the extent to which your own emotions are influenced by variations in thresholds (as affected by the physiological conditions mentioned) as compared with variations in the stimulus situations.

3. Make a list of those aspects of emotion that you expected to have discussed in a chapter on emotion, which you did not find here. Analyze in each case the probable reasons why the particular aspect did not receive analysis.

4 List the popular misconceptions regarding emotion which you have absorbed and which you found counteracted by your study of this chapter.
5 Read the abstracts of researches in the field of emotions in any three issues of *Psychological Abstracts*, making note of the problems you find being analyzed and experimented upon which were not mentioned in this chapter How much overlapping is there between these and your list in question 2?
6 Devise a simple experiment which could be carried out on children between the ages of one and two to determine differences between expression of fear and expression of anger
7. Outline what seem to you to be the functions of emotion in civilized society, and what obstacles emotions present to effective living.

CHAPTER VI

THE MEASUREMENT OF EMOTIONS AND FEELINGS

Measurement of emotional response means measurement of bodily changes which go with emotion.—Emotion varies in degree of intensity. To measure the intensity of the emotional response to a given stimulus, we measure the bodily changes which accompany the emotion. This will not always give perfect agreement with the person's own report on the intensity of his emotional response, but the relation between the two is usually rather close Moreover, the study of the relation between the subject's report and the intensity of his bodily response is of practical value as well as of scientific interest, for it helps toward an understanding of what an emotional response really is All the physiological methods about to be described presuppose comparisons back and forth between the behavior and the subjects' reports.

Most of these bodily changes depend chiefly on the autonomic nervous system.—Among the physiological changes the pulse rate has always attracted attention. The force of the heart beat is now studied by the electro-cardiograph which makes a delicate record on a revolving drum. Changes in blood pressure are also very important as indicators of emotion Blood pressure varies from moment to moment, depending upon the whole activity of heart and arteries The systolic blood pressure is the pressure when the arteries are subjected to the maximum pressure due to the contraction of the heart, and the diastolic blood pressure is the pressure when the relaxation of the heart has caused the arterial pressure to reach its lowest point. Both the systolic and the diastolic blood pressure are extremely responsive to emotional conditions, particularly fear A very brief interval may produce a measurable change in either form of blood pressure. In general, times

of emergency and stress involve a great decrease in the diameter of the arteries, with a consequent rise in the blood pressure. As we have already seen, these changes are directly related to the activity of the sympathetic division of the autonomic nervous sys-

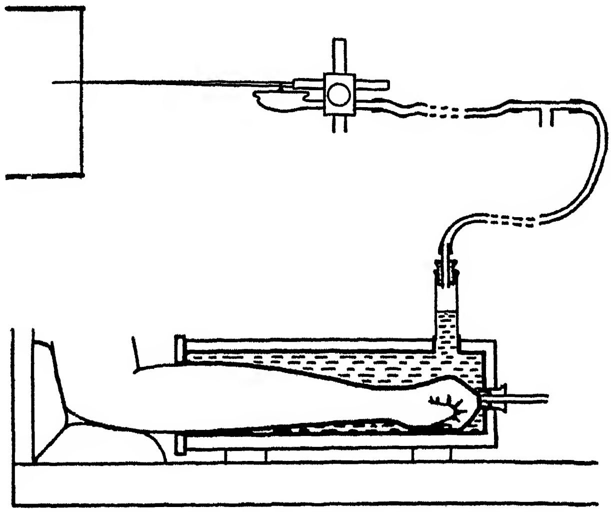


FIG. 23—Apparatus for measuring the volume of a limb. This is a form of plethysmograph adapted for measurement of the size of the arm as the blood supply to the arm varies The arm is in a water-tight compartment. The tubing system is air-tight and is so arranged that changes in the volume of the arm will alter the position of the pointer in the upper left-hand corner of the figure When blood supply to the arm increases as a result of some sort of stimulation, the arm increases in volume, forcing the water up in the tube, increasing the air pressure in the system; this raises the pointer, which is recording on the smoked-paper surface of a revolving drum. Later, by looking at the line on the smoked drum, one can see precisely when the change in volume occurred and also get some index of the amount of the change Redrawn and simplified from H Eng, *The Emotional Life of the Child.* Oxford University Press.

tem (compare page 73). Many things besides emotion affect the systolic and diastolic blood pressure, and it is important for the experimenter to make sure that none of these disturbing factors is confusing his result. In the absence of physical exertion or organic disease, a marked change in the systolic or diastolic blood pressure is often a useful indicator of emotion.

During emotional reaction the distribution of blood in the limbs is greatly altered. Often the variations in the amount of

blood present in the hand and forearm are sufficiently great to make possible the direct measurement of such changes by means of a plethysmograph. One model is shown in Fig. 23. The figure shows how the swelling of the hand and arm (as the smaller blood vessels dilate) *raises the water level*; and this, by means of an air chamber and attached rubber tube, makes possible a continuous record on a revolving drum. Because of the activity of the heart and blood vessels, many emotional responses can be measured by this device, but only roughly since the lag or delay in physiological response is often great.

The inspiration-expiration ratio increases during emotion.—Changes in breathing also merit emphasis as rough indicators of emotion. The ratio between the time taken to inhale and the time taken to exhale (including the quiet period before a new inhalation) is usually about 1 to 4; but during intense emotion it may rise as high as 1 to 2 or even 1 to 1. Because of this fact, some experimenters have thought that a lie-detecting device could be devised for cross-examination purposes: Questions whose subtle implications frighten the guilty person but are meaningless and "innocent" to an innocent person lead to hastily constructed misstatements or evasions, but the physiological responses betray the suspect Results from other experiments with this method have not been so clear. It is safer to emphasize the significance of the inspiration-expiration ratio in relation to the measurement of emotion in general, rather than to insist on its significance in relation to the special problem of lie detection. The lies of seasoned liars tell very little about emotion, even their inner physiological responses may be unaffected

Emotion alters the association of words in the free association test.—In the "free association test," a series of words is read to the subject, who gives in each case the first word that comes to his mind. Typical responses of college students are:

Stimulus	*Response*
table	chair
dark	light
mountain	valley
sleep	dream

The chief value of the free association test is in the study of the emotions of abnormal as against normal persons. Jung at Zurich succeeded a generation ago in showing that many persons with nervous troubles, particularly of an emotional origin, would respond to particular words in such a way as to make clear the origin of their trouble. In the case of a person suffering from a nervous breakdown, for example, obsessed by a worry whose basis he cannot make clear and ignorant of the cause of his difficulty,

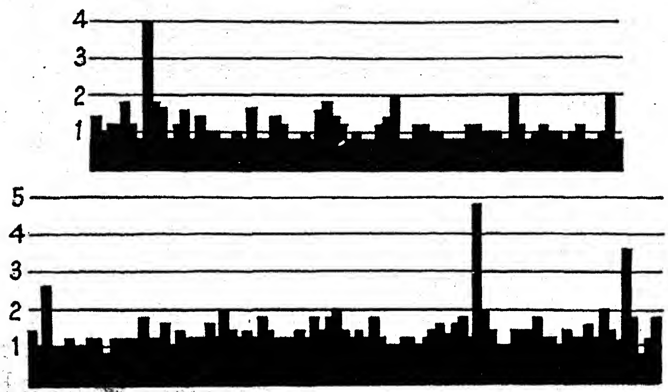


FIG. 24a.—Reaction times in an association experiment for two normal people. The time is measured that elapses before the subject says a word in response to the word which the experimenter gives him. Each column in the series of reactions, reading left to right, represents a separate reaction, and the height shows how long the reaction took. The time is measured in units of one second. These may be assumed to be normal types of reaction, with which can be compared such performances as those in Fig. 24b. From C. G. Jung, *Amer. J. Psychol.*, 1910, vol. 21, p. 222. By courtesy of the editor and the author.

it is found that some words in the list prepared by Jung touch off responses with a definite emotional coloring. The words given in response may themselves directly portray the emotion, as when an impersonal word like "hand" leads to the response "horrible"; or it may be shown through reference to some subjective factor, as when the person follows common nouns like "table" or "dog" with terms like "myself" or "my." These little indications are not taken separately and exalted to the level of diagnostic signs. Rather, the whole picture is studied together and the person

is shown what the emotional drift was which led in one case, for example, to an emotional outburst and in another case to a prolonged series of words with exclusive reference to himself. Jung found also that in many cases the word, although provoking a response word which was colorless and of no special significance, might lead to various "complex indicators" such as blushing, sighing, repetition of the stimulus word or of a previously given response word, grossly exaggerated reaction time, and the like; perhaps the most frequent of all is the makeshift of pretending not to have understood the stimulus word (though a later reply may make quite clear that it was understood but dodged because of some emotional stress) The important thing about these methods is that they show the patient what he himself would not have guessed about his own emotions. Compare Figs 24a and 24b, showing irregularity in reaction time resulting from emotional upheavals produced by the stimulus words.

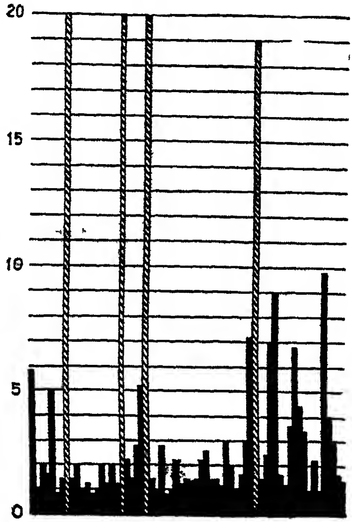


FIG. 24b—Reaction times in an hysterical individual. Time is again measured in seconds. Note that many of the responses took much longer than did the responses of the normal subjects, Fig 24a The cross-hatched columns indicate places where the subject was unable to react at all From C G. Jung, *Amer J. Psychol.*, 1910, vol 21, p 226 By courtesy of the editor and the author

Emotion reduces resistance of the skin to electric current, producing the "galvanic skin reflex."—If a small electric current is sent through the body it is found that the resistance of the body to the current decreases with increased emotion; this can easily be shown with a galvanometer. To this change in body resistance the name *galvanic skin reflex* (or psychogalvanic reflex) is applied. Small voltage, usually 4 to 6 volts, is used Normally, the body resistance to this current is very great; it

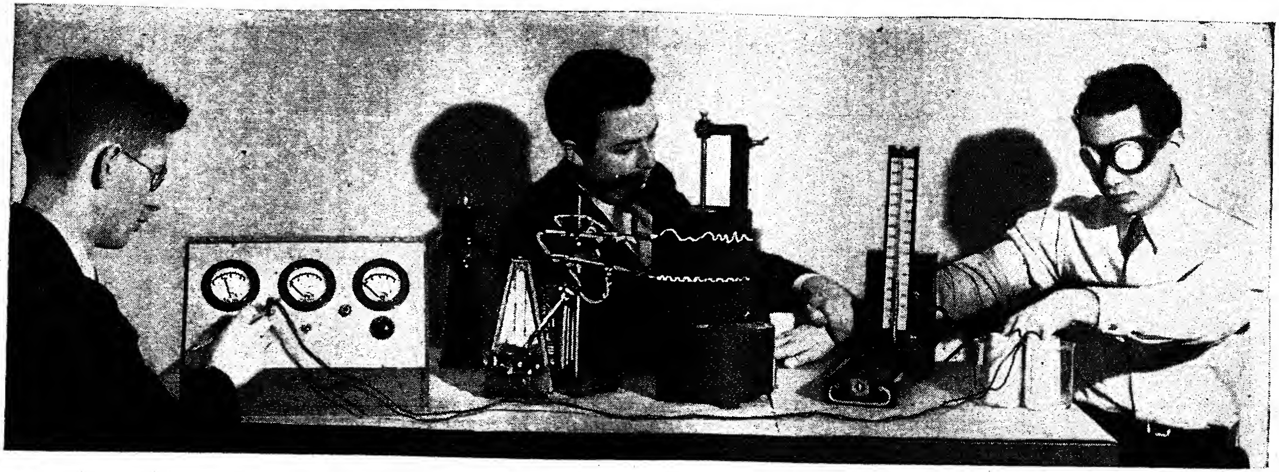


Fig. 25.—Apparatus for measuring physiological changes in emotion. The subject is at the extreme right, and is wearing goggles with opaque lenses to prevent him from seeing what is going on. The fingers of his left hand are dipped into cups which contain fluids that act as electrodes, i.e., they can conduct electricity. The wires leading from these cups to the box at the other end of the table bring the subject into an electrical circuit. When the resistance of the skin to the flow of electricity decreases, more current flows in the circuit, and the pointers on the dials start moving, showing the change in current. This change in resistance is the galvanic skin reflex. Around the subject's right arm is strapped a sphygmomanometer, a partially inflated rubber sleeve, which forces the mercury column (next to the electrode cups) to rise as the blood pressure in the arm increases. Across the chest of the subject is strapped a flexible rubber tube called a pneumograph. This is connected in an air-tight system with a chamber near the smoked drum, in the middle of the table. The chamber has as one of its sides a rubber membrane which falls when air pressure in the system is lowered and which rises as the air pressure increases. There is a marker attached to the membrane which records the ups and downs on the drum. The changes in air pressure are caused by the subject's breathing in and out, and we have a recording of his breathing by means of this pneumograph system. The metronome beating closes an electrical circuit at the end of each swing. The making of this contact is recorded on the drum so that a measure of the timing of breathing can be gotten by comparing the upper record, the breathing, with the even, regular, lower line caused by the metronome. Courtesy of F. C. Thorne.

appears to be due almost entirely to the skin (the subject does not even feel the current) Since the skin resistance is so large, it follows that what happens in the skin will be the chief single cause of what happens to the electric current. The formula for a direct current is: *Amperage of current equals voltage divided by ohms;* since we know the voltage, the measurement of the current in amperes makes possible the direct study of the way in which the body resistance varies in ohms. The needle of the galvanometer is at zero if the subject is in a relaxed state so that his body offers a constant resistance. This zero point represents, of course, the amount of current under these neutral conditions when no emotion is present. The emotion-rousing stimulus quickly lowers the body resistance and the needle swings through an arc whose magnitude reflects the amount of physiological disturbance Fig. 25 shows this method in combination with other methods. Great decreases in skin resistance are found to appear when emotionally toned words, or other emotion-rousing stimuli, are presented Sudden noises, shocks, or other fear-producing stimuli may be used. The swing of the needle is observed and recorded. A permanent record showing the amount of the swing of the needle can be made by means of apparatus which is too complicated for description here. Permanent records of the variation of skin resistance are shown in Fig. 26.

Whether these body changes are directly due to emotion *as such*, or whether they are the expression of a stirred-up bodily condition of which emotion is only *one aspect*, is a debated question, the answer to which is tied up with the problem of an exact definition of what emotion is It has been maintained by some authorities that striving or effort, rather than emotion strictly speaking, is the basis for the galvanic skin reflex Even slight *effort*, apparently without emotion, may produce the reflex. Since a great many things disturb the autonomic nervous system we should expect that the galvanic skin reflex would sometimes record and measure things which are only partly or not at all identical with what we ordinarily call emotion. On the other hand, it is easy to produce emotions in a laboratory; and when we have produced them and

know that they are manifestly there, because they are evident both to us and to the subject, it is fair to say that the accompanying galvanic records are a rough indicator of the physiological changes which have been experimentally produced. This is not saying that the emotion is the only thing which affects the galvanometer, nor is it an answer to the very complex physical question as to the full

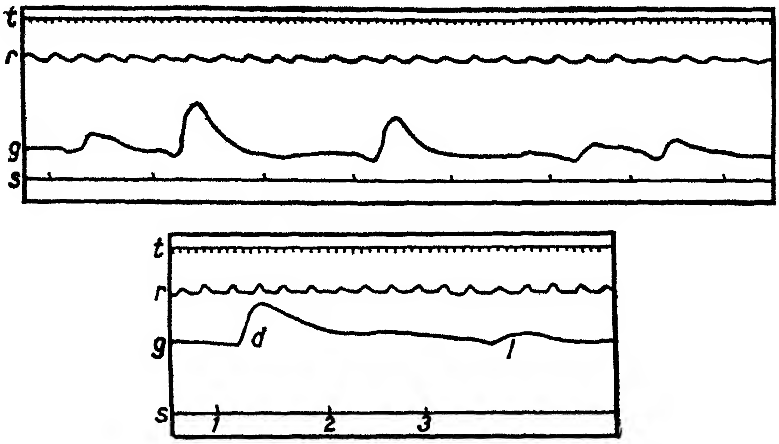


FIG. 26—Records of the galvanic skin response. A beam of light, delicately controlled by the electrical changes in the body, leaves a permanent record on a revolving drum The subjects from whom the records were taken in this experiment were not instructed to make any motor response at all, they had nothing to say or to do Lists of words were read to the subjects, a horn was suddenly sounded, pin pricks were threatened and administered These records show the time of stimulation (*s*), the galvanic curve (*g*), the breathing curve (*r*), and the elapsed time (*t*) The galvanic reactions follow the stimuli directly, varying somewhat in the amount of the response, but taking a regular form The second record shows a direct reaction (*d*), coming within the usual interval of 1 5 to 2 seconds, and a late reaction (*l*), occurring more than 4 seconds after the stimulus word. From H C. Syz, *Brit J. Psychol*, 1926, vol. 17, between pages 60 and 61 By courtesy of the editor

explanation of these electrical changes. It remains true that for most persons in well-controlled laboratory experiments where emotion rather than effort is the thing directly aroused—for example, by music—emotions may be roughly "measured" by this method For example, a group of subjects, estimating the degree of their emotional response to a large number of different stimuli, gave galvanometer deflections which averaged high for strongly

felt responses, low for indifferent experiences, and in between the two for emotional experiences of moderate strength. Emotional stimuli which are closely similar to one another produce galvanometer deflections which are also very similar.

How can skin resistance be a measure of emotion? This is possible because the expression of emotion depends upon the autonomic nervous system, which regulates the activity of the glands, both duct and ductless. The activity of the sweat glands is an important indicator of autonomic activity, and recent experiments show that it is the action of the sweat glands that lowers electrical resistance One reason for believing that the galvanometer is important as a clue to the measurement of emotions is the fact that the results with the galvanometer, respiratory index, blood-pressure indicator, etc., are consistent if the experiment is well controlled In Blatz's experiment, for example, mentioned on page 84, a quiet dead level existing in all the forms of activity present in the test was suddenly interrupted when the subjects were frightened, and *all the changes occurred together.*

These methods supplement one another if used in conjunction.—It will be recalled that the autonomic nervous system is something like a "nerve-net"; consequently an upset individual should be expected to show an *all-round upset* involving blood pressure, pulse, breathing, electrical changes due to the sweat glands, etc. In a certain sense, then, *any* avenue of approach to the activity of the autonomic nervous system is an avenue of approach to the measurement of emotion if other things affecting the autonomic system are controlled. We have, however, emphasized the fact that emotion is largely dependent upon a certain part of the central nervous system, namely, a certain small region near the front end of the brain stem It seems likely, therefore, that what we are measuring when we measure emotion is not the physiological change which is *most directly related* to the experience of the emotion itself, but rather the bodily changes which *follow* upon the arousing of the emotional state. Accepting Cannon's view that the main center for the emotions is in the brain stem, we shall have to assume that it is only after these changes

in the brain stem have caused an upset in the autonomic nervous system that we are able to measure the emotional response.

SUMMARY

The degree of activity of the autonomic nervous system during emotional responses may be measured. Among the most important and most easily measured of the changes due to autonomic activity are increases in pulse, blood pressure, and respiratory rate. The activity of the sweat glands causes a reduction of body resistance to electric current, known as the galvanic skin reflex. This method, especially in conjunction with the association test, is a valuable clue to the degree of emotion in the subject. No single method is reliable when taken alone; when used together, and in conjunction with a study of the subject's reports, they give valuable results.

REFERENCES

Eng, H., *Experimental Investigations into the Emotional Life of the Child Compared with That of the Adult,* 1925.

Smith, W. W., *The Measurement of Emotion,* 1922

Symonds, P. M., *Diagnosing Personality and Conduct,* 1931.

PROBLEMS

1. Make a chart of the methods of measuring emotion described in this chapter, with headings for the advantages and limitations of each Add a paragraph stating which method seems most likely to reveal important information about the nature of emotion, and justify your answer.
2. If you were given $50,000 for research in the measurement of emotion, how would you spend it? Outline a plan including the kinds of problems already attacked that you would carry further and the kinds of problems on which you would initiate new research, showing both the theoretical significance and the immediate practical value of each
3. On what important emotions has practically no research involving measurement been described here? Can you think of any techniques by which these emotions might be measured?

CHAPTER VII

THE SIMPLER SENSES

ORGANISMS are in such constant interaction with their environment that it is a little artificial to separate what the environment does to them from what they do to the environment Yet we have had to make such a distinction, and we have been discussing what they do, their motivated and emotional responses to the world about them We shall now consider the processes by which the environment stimulates them, the way in which they pick out and use the lights, sounds, smells, changes of temperature, and so on, which the environment keeps thrusting upon them

Since the body is being constantly stimulated by physical energy (light, heat, etc) in a great many ways, the classification of modes of stimulation must be in terms of the kinds of energy which can act as stimuli upon the kind of bodies we have. Of the scores of types of energy which act upon the cells of the body, both without and within, relatively few produce specific and definable changes in our experience or in the posture or movement of our bodies Many familiar types of energy now easily manipulated in the laboratory, such as X-rays and radio waves, pass through the tissues with but little or no effect as stimuli.

One might think of all the radio waves from the broadcasting stations which are passing through the room we are in, of which our senses do not make us cognizant. It is only in recent years that we have known of electromagnetic waves and have been able to translate these into sound waves after they have traversed long distances. It is only by *indirect methods*, such as the changing of

these waves into *light* or *sound*, that we can come into contact with this part of our environment.

Sense organs contain sensory cells which have low thresholds for certain kinds of energy.—In the course of evolution gradual changes in structure have occurred which permit undifferentiated cells to specialize for various functions Certain cells in the skin, for example, become slightly more sensitive to light vibration than are those near by. The first eye is simply a group of slightly more sensitive cells Increasing sensitiveness to pressure makes possible the similar differentiation of what later becomes the "sense of touch" In the nose and mouth, as early as these can be identified, specialization of cells appears, permitting chemical reaction between certain body cells and the food substances which the animal smells or eats, and here again the specialization ultimately goes so far that the group of cells which serves these ends seems to have no task but to carry out this one particular purpose. We might say that every sense organ is a group of cells specially sensitive to a particular kind of stimulation, some particular kind of energy (e.g., chemical, mechanical, electrical, etc.). These low thresholds permit selection from among stimuli "Stimulation," or whatever we may care to call the organism's sensitiveness to the energy acting upon it, consists of a selection of a few stimuli from a complicated pattern of things outside the body. The very fact of responsiveness to stimulation means selection; and in organisms having more than one cell this selective function depends on specialized structures, some cells being adapted to receive some kinds of energy, others being adapted to receive others.

The intensity of sensation depends on (a) number of nerve fibers excited; (b) frequency of impulses along the nerve fiber.—When activity in a sense organ arouses a sensory (incoming) nerve fiber, the latter is subject to the general law that *any nerve fiber must either respond with its whole capacity for response, or not respond at all.* This is the "all-or-none law" of nerve action. The grading of intensities of response must therefore

be achieved by one or the other of two methods, through variation in the number of nerve fibers which are aroused at a given time, or through different frequency of nerve impulses which are carried along the nerve fibers. Regarding the first alternative, it is easy to see that the degree of intensity of a given response will depend on the number of elements excited. Just as the vigor of a muscular contraction depends upon the number of active nerve fibers which set going the cells of the muscle, so the effect of a stimulus depends partly upon the number of sensory nerve fibers which the stimulus excites. This, however, is only half the story. An intense pain does not differ from a mild pain simply in the number of nerve fibers which are active On the contrary, experiment shows that intensity of pain is correlated with the frequency of nerve impulses along the nerve fibers. The term "frequency" does not mean the rate at which the impulse travels along, but the number of impulses passing a given point within a given time unit, such as a second. So to speak, it is not how fast the messenger runs, but how much distance separates the different messengers who are running along the same path one after another, each at a constant speed. Along one road there is a messenger every half mile; along another road a messenger every hundred yards. The basis for different frequencies is this: After a single wave of excitation is set up in a nerve fiber there is a very brief period before the nerve fiber can receive another stimulation. Consequently, since a message has started out over the fiber, the next one must wait This waiting period during which the nerve cannot conduct is called the *refractory phase*. This waiting interval is, however, very short, so that waves usually sweep after one another at a rate of many hundred per second. The rate at which impulses may succeed one another along the fiber is not fixed for any one nerve fiber Any given fiber varies greatly in the rate at which it permits the impulses to go through. Impulses may be crowded together after one another several times as "thickly" in the case of intense stimuli as in the case of weak stimuli. What we call in psychology the intensity of sensation is due largely to the number of impulses passing along a fiber or team of fibers all

serving the same function in a given time. This relation between intensity of sensation and the frequency of impulses along a fiber is called the *Adrian principle.*

The quality of sensation depends on the nature of the brain response or "specific energy."—*Quality* of sensation is an entirely different problem. What is the physical basis for the qualitative differences between sensations such as red and green? The fact that the wave length of red is greater does not mean that there must be a more rapid passage of nerve impulses along the fiber. The *brightness* of red light might be expected to alter the frequency of the impulses, but the *difference in quality* between red and green cannot reasonably be regarded as producing a characteristic and unvarying difference in frequency of nerve impulses. Suppose a fiber in the optic nerve is relaying the impression given by a red light and another fiber is relaying the impression given by a green light; for the purposes of the present argument, both are sending their impulses at the rate of 200 per second. How do we know what color the object has? What is it in the nervous system which makes the difference between red and green? If nerve fibers are alike, and if they are delivering their impulses at the same tempo, how is there any distinction among all the various qualities which come from our senses?

This question was shrewdly analyzed by the German physiologist Johannes Muller a hundred years ago, and his answer to it is called the doctrine of "specific energies" of nerves. We shall take the liberty of stating the view not in the exact form proposed by Müller, but as it is now held by many psychologists, amending it in one respect in which we know that Muller guessed wrong The modern theory of specific energies is this: The different *parts* of the brain, when physiologically active, become the basis for different qualities of experience. The visual area in the occipital lobe in the back of the brain will give visual experiences like color A tumor on the visual area may give rise to a visual hallucination; chemical excitation, as from drugs such as opium, will also cause visual hallucinations. Mechanical jarring, such as falling on the back of the head, will give flashes of light. *Whatever* you do to

the visual area, you always get from it not sound or touch qualities, but visual qualities.

The optic nerve connects the retina with the visual area. The sense organs in the retina have low thresholds for light, and the optic nerve leads only to the occipital lobe at the back of the brain, so that when light gets into the eye it is inevitable that the visual center in the occipital lobe should be excited. This center has only one way of responding. It responds by giving visual impressions. As we saw, *any* kind of stimulus that will get *action* from the visual center of the occipital lobe will get *visual action.* This part of the brain is chemically suited to give only those qualities which we call visual qualities. In exactly the same way, the auditory region in the temporal lobe of the brain is so constituted chemically that when it is excited by a tumor or a blow or a chemical change it gives qualities of tone and noise. The low thresholds for tone and noise in the mechanisms of the ear result in stirring up the auditory centers, whereas the same tones and noises are not connected by any pathway leading to the visual area. To respond to sights and sounds by making reflex reactions is one thing, depending upon certain relatively simple connections; but to get visual and auditory *qualities of experience* depends on having a brain so specialized that one part of it when excited gives visual qualities and another part when excited gives auditory qualities.

One may push the theory further if he wishes. The visual and auditory areas, and all the other sense areas, are subdivided. Parts of the visual area when excited give red, others green, etc. Parts give light gray, others dark gray, etc. The subdivision may be made as complicated as one likes The *qualities of experience* are basically the result of certain *special and localized activities in the brain.* Part of each sense area can, when excited, give us one particular quality, but no other. If we had somewhat different brains, different qualities would make up our experience. It is entirely possible that we might respond effectively to light waves without ever having the kinds of color experience which we actually do have We might, for example, respond to light by

experiencing various sorts of tingling sensations; and experiences of color and brightness might come to us while touching various kinds of surfaces in the dark. This notion that the quality of the brain response is the basis for the particular kinds of quality experienced has led to some extraordinary paradoxes, for example, it has long been remarked that if the auditory nerve could be connected with the visual center, and the optic nerve connected with the auditory center, we should see the thunder and hear the lightning. And, we might add, appropriate connections would make it possible to taste weights, to smell cold breezes, or to compare the pressure exerted by the song of two distant birds.

The skin senses consist of (a) touch, (b) warmth, (c) cold, (d) pain.—One of the most stubborn and misleading psychological traditions is the one regarding the "five senses" of man: sight, hearing, taste, smell, and "touch" In reality the senses acted upon by the skin, the muscles, and the interior of the body are numerous and in many ways important for psychology; they deserve individual study, and cannot all be lumped under the general name of "touch." The skin alone contains four senses.

Systematic exploration of the skin senses is usually carried out by marking off a small region (a square inch or so subdivided into 100 small squares) on some easily accessible part of the body such as the forearm. The subject's eyes are closed. A metal instrument with a point and shaft, heated to a standard temperature—let us say, 43° C. (107° F)—is brought down lightly upon the various little spots (squares) which have been marked off within the larger square.

The subject says "warm" if he notes a warmth sensation; "touch" if he is aware of a touch but does not get warmth sensation The majority of the spots are completely insensitive to warmth, so that on completing the exploration of this region the warmth spots, i e., the spots definitely responsive to this kind of stimulation, will be marked off about as shown in Fig 27. Now the instrument is chilled and the same procedure is followed. The subject reports "cold," or often simply "touch."

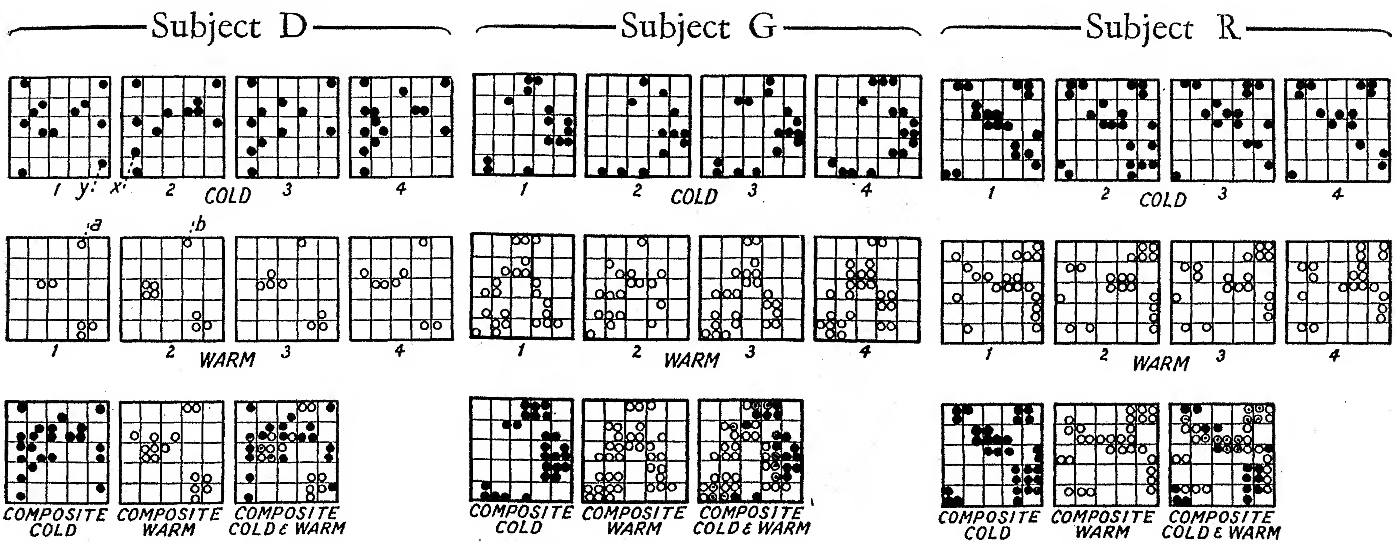


FIG. 27.—Location of temperature spots. Spaces 1 cm. sq. with cross-section lines 2 mm. apart were stamped on the skin of the upper arm of three subjects, D, G, and R. These areas were explored and mapped out for their sensitivity to temperature sensations at four different sittings for each. The maps for each of the sittings are given above, together with composite maps which combine the four sessions. These maps give a good idea of the way in which sensitivity to warmth and cold is distributed in the skin, and the variation between individuals; they indicate very clearly, also, how a single individual may vary from day to day. From K. M. Dallenbach, *Amer. J. Psychol.*, 1927, vol. 39, pp. 417, 418, 420. By courtesy of the editor.

One of the first things to strike the observer is that "the temperature sense" is not just one sense Many spots can differentiate warmth from touch, but cannot differentiate cold from touch, and conversely.

Neither the warm nor the cold stylus is an ideal instrument for the exploration of touch; if we want to study touch for its own sake, it is better to use a light bristle held in an instrument which permits the pressure to be exerted in a uniform way in a direction exactly perpendicular to the plane of the skin. Touch spots are now found to be much more numerous than either warm or cold spots. Not only are many of the spots which have been classified as either "warm" or "cold" responsive also to touch, but many of the squares that have been blank, that is, those in which neither of the temperature stimuli was received, serve as touch spots. A needle is used in the same way for the exploration of pain spots These are shown to be even more numerous than the touch spots.

The description thus far has offered no theory about sense organs in the skin. The fact that certain spots are responsive to touch and not to temperature certainly implies that there are receptors, or sense organs, capable of yielding touch sensations, and suggests that the only reason why one of these little squares may give rise to both warm and touch or to both cold and touch is that the squares are too large to allow the isolation of the true receptors It seems almost a necessary result of this analysis to say that there are four different kinds of sense organs serving the functions of transmitting warmth, cold, pressure, and pain. The nature of these sense organs is being actively investigated at present.

Warmth spots are excited by warm stimuli; but the cold spots may be excited at the same time if the temperature of the stimulus is high. If several cold and several warmth spots in a given region are stimulated simultaneously, the result is not a "lukewarm" experience. It is, paradoxically, the experience of heat. When a warm stimulus gets warm enough to excite not only warmth spots but cold spots too, the peculiar result is the heat experience,

which we have learned to consider the result of a stimulus which is still "more warm than a warm stimulus." By simultaneously

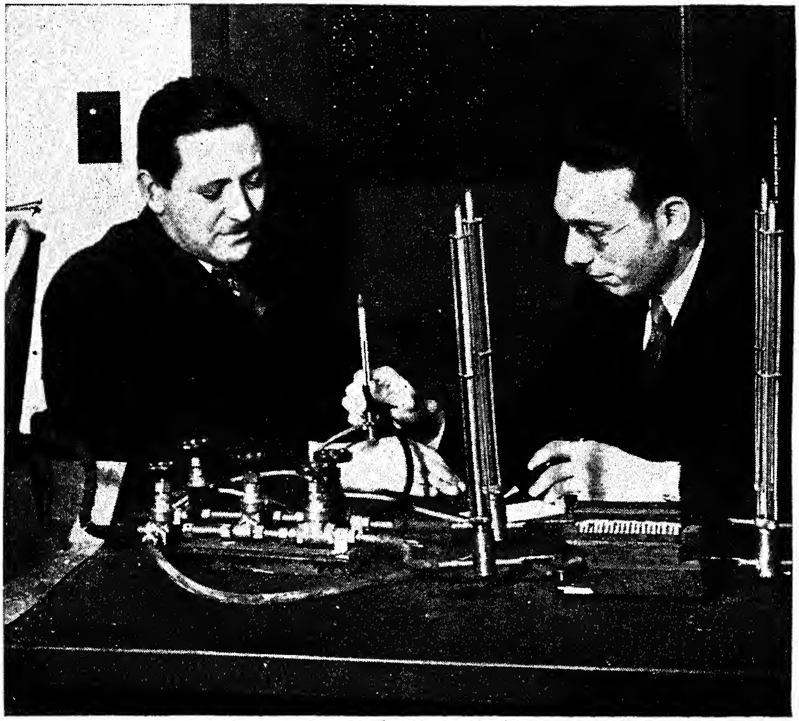


FIG. 28.—Materials for studying sensitivity to temperature differences. The experimenter (right) is exploring an area outlined on the back of the subject's hand and recording the results on a chart; see Fig. 27. The stimulus is a metal cone through which water is passing. The temperature of the stimulus may be varied by passing warmer or colder water through the system. The temperature is indicated by the thermometer which also serves as a handle for the instrument.

Directly in front of the experimenter's left hand is another interesting piece of apparatus. This is a grill formed by a series of metal tubes. The tubes are arranged in two systems. Through the alternate bars of the grill, hot and cold water is flowing. When the bare arm is laid across the grill there is physically the application of warm and cold stimuli to nearby areas of the skin. *The psychological reaction to such a combination of stimuli is the experience of heat.* By courtesy of Meyer Koch and K. M. Dallenbach.

stimulating warmth spots by moderate warmth and cold spots by moderate cold it is easy, with the proper technique, to produce

the experience of heat Improved devices have been worked out for the simultaneous stimulation of cold and warmth spots Fig. 28 shows the way in which warm and cold water is used to hold the stimulus points at the right temperature for such an experiment. (See the latter half of the caption.)

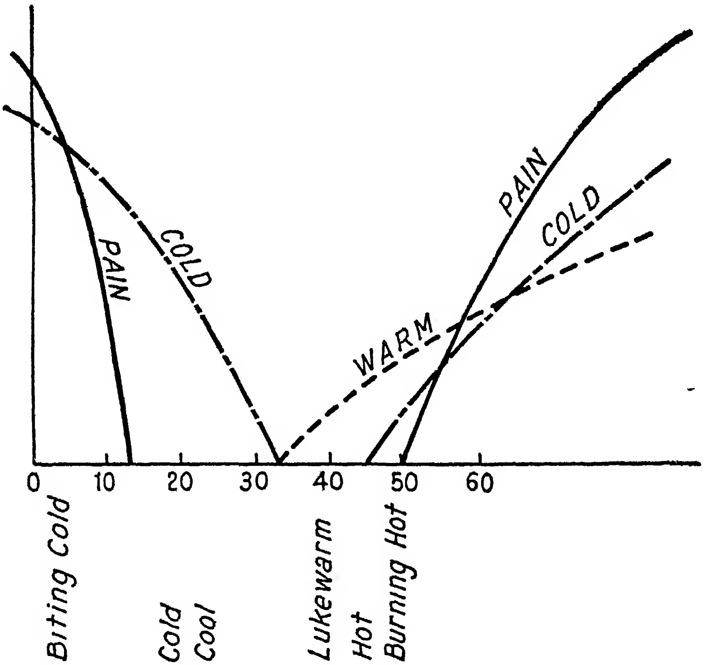


FIG. 29—The response to different temperatures The base line shows the physical temperatures in degrees Centigrade Above is the physiological scale showing the relative amount of response which the different sensory organs are estimated to make Below is the general psychological scale This chart, for example, reads that at 40° C, the warmth receptor is moderately active and a person would say the stimulus was lukewarm, at 60° C, the warmth and cold receptors are very active and the pain receptor is participating in the reaction too, so that the subjective response would be that the stimulus was burning hot. From von Frey.

With another device a large number of *cold* spots (no warmth spots) may be stimulated simultaneously by one presentation of the apparatus carrying *warm* water, so that extensive cold is experienced over precisely the area where there is, from the point

of view of physics, extensive warmth. Sense organs have exceedingly low thresholds for one kind of stimulation, and high thresholds for all others; but the cold spots are in this experiment excited by warm stimuli, and when once they are excited the nerve fibers connected with them deliver to the brain exactly the same kind of message they would deliver if they had been

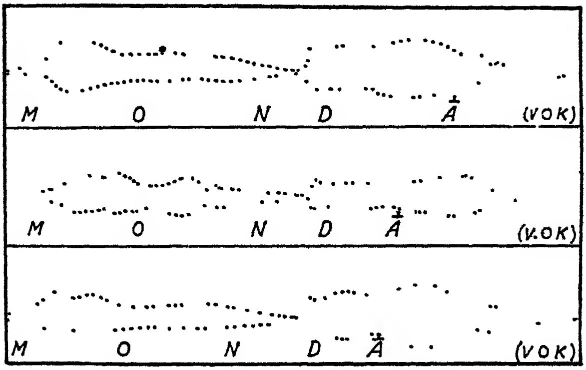


FIG. 30a—Patterns of variation in the *intensity* of sound in a single word. The word "Monday" was said three times in succession The recording device used was such that the words were transformed into a wave-like record. The record represented intensity of the sound by the amplitude or height of the waves Inking around the top and bottom of the records emphasizes variations in the height of the curve (vertical distance between upper and lower dotted lines) at the different parts of the word, height variation thus represents variations in intensity Note the constancy of the pattern represented by these records of the same word spoken by the same speaker From V. O Knudsen, *J. Gen. Psychol.*, 1928, vol. 1, p 343. By courtesy of the editor.

stimulated in the ordinary way by cold This is "paradoxical cold." Fig. 29 shows the relation of temperature to the different sensations under everyday conditions.

So delicate is the response of the skin that different sound properties can be recognized by the deaf by the use of a five-finger vibrator; this method is used to supplement lip-reading. How much can be done ultimately in a practical way toward complete reeducation of "hearing" in the deaf is far beyond the possibility of present solution, but it should at least be noted that the capacity for differentiation of vocal sounds by means

of touch is in a general way similar to the skin sensitiveness which has enabled the blind to be trained to read fairly rapidly from raised "domino patterns" on a surface. The vibratory sense,

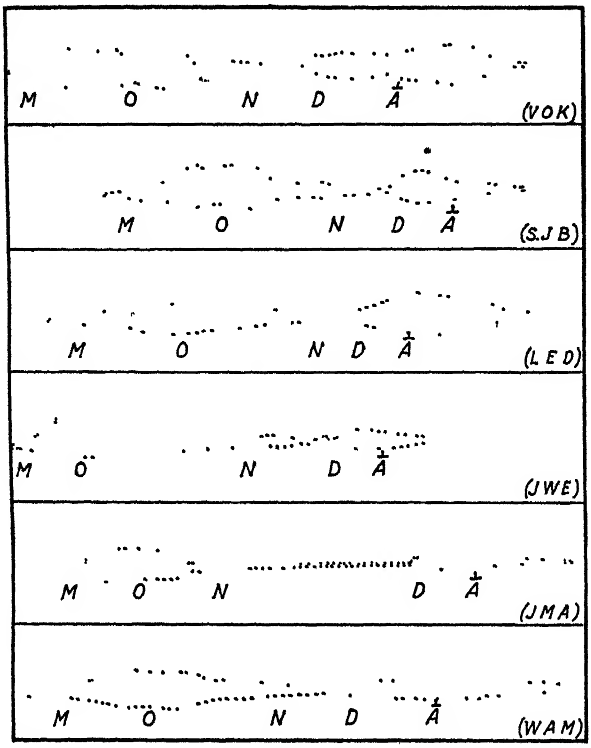


FIG. 30b.—Intensity patterns of the word "Monday" as spoken by six different speakers. These records suggest the similarity as well as the differences in the manner of saying a given word The first part of this word seems to be spoken loudly by all the speakers Though there is a distinct difference in the intensity with which the last part is said, there does seem to be a general pattern for the word From V. O Knudsen, *J Gen. Psychol.*, 1928, vol 1, p. 344 By courtesy of the editor

however, as shown in training the deaf to identify different vocal sounds, strongly suggests that the response here is as different from that of ordinary touch as "deep pressure" is from light cutaneous touch sensation The vibratory impression is so much like the rapid beating which sound itself produces on the ear-

drum that some observers actually mistake tactual vibratory impressions for sounds. Figs 30a and 30b show "envelopes" of sound, depending on variations in *amplitude* of vibration (not pitch) as different words are uttered.

Though the number of elementary cutaneous sense qualities is probably only four, nevertheless qualities of hardness and softness, smoothness and roughness, even wetness and dryness, are perceived Softness and hardness, for example, have been resolved experimentally into experiences of touch and temperature. Hardness results from (a) pressure of the same intensity throughout the stimulated area, (b) the presence of well-defined boundary lines, (c) coldness; while softness results from (a) varying pressures, (b) indefinite boundaries, (c) warmth.

Here we are dealing not only with sensations, but with the *interpretation* of sensations, to which we give the name "perception." In many cases sensations from different sources may give rise in this way to *perceptual wholes* which betray no diversity of origin Only under conditions of controlled experiment and with careful *introspection*, i e , *description of one's own experience,* can the complex nature of the impression be shown.

Organic sensations are derived from the vital organs.— Warmth, cold, touch, and pain sensations are probably aroused by stimulation within the body in much the way that they are aroused on the skin. There are a number of other "organic sensations," such as hunger, thirst, sex feelings, fatigue, disgust, and so on. From what has been said about hunger and thirst, it seems reasonable to believe that these organic sensations depend partly upon the compounding of simple sense qualities. Hunger, for example, may be largely just a matter of tactual stimulation from the stomach; but whether the four cutaneous qualities are adequate to account for such apparently unique experiences as nausea and fatigue is uncertain.

Kinæsthetic sensations report the position and movement of those parts of the body which are controlled by the striped

muscles.—In addition to impulses arousing the sense of touch, there is a variety of incoming impulses which give us awareness of bodily position and movement, the sense organs for which are located in muscles, tendons, and joints. This awareness is the "kinæsthetic sense." Motion at the joint, through as small an arc as one degree, may often be noticed The sensations from the muscles of the arm tell us rather well how far the arm has moved; but the slower the movement the greater the apparent distance. The gauging of distance by the kinæsthetic sense is, however, inferior to that by the eye

Diseases which block off the incoming fibers from the muscles make skilled movements impossible (some patients, however, can carry out these movements under the direction of their eyes). A man who had lost all kinæsthetic and skin sensation from the leg willed to move the leg and, since he was not looking at it, thought he had moved it though the experimenter held it still; there was no kinæsthetic report upon which to rely. Locomotion, the maintenance of posture, and the accuracy of skilled acts all depend greatly on these incoming kinæsthetic impulses. As we shall see later, the training of our muscles is possible only if the muscles can keep reporting their position and movement

Smell and taste are closely related to each other; much which is often attributed to taste is really due to smell.—The number of identifiable odors runs into the hundreds, and probably into the thousands for most persons. Yet, on the basis of the systematic comparison of different odors in terms of their similarities and differences, it has been found possible to group the primitive or simple odors in six main types, as suggested in Fig. 31 If we name the six classes, *flowery, foul, fruity, spicy, burnt, resinous*, we can place any odor in its proper position by comparing it with these others. Sometimes an odor resembles not only one but several of these six types of odor Henning has made up a figure to represent this fact It will be evident that an odor which would be classified as being in the middle of the front face would be somewhat flowery, somewhat fruity, some-

what spicy, and somewhat resinous. There are critical points, points at which a progression has been evident from one odor to another, but at which no further progression is possible unless the direction is suddenly changed. Odors are to be found between "flowery" and "spicy," but when one gets to the "spicy" he can go no farther in this direction. One finds that there is also a gradation of odors from the "spicy" to the "resinous," etc.

Smell is probably more subject to quick "adaptation" than any other sense. The plumber's inability to smell gas while repairing

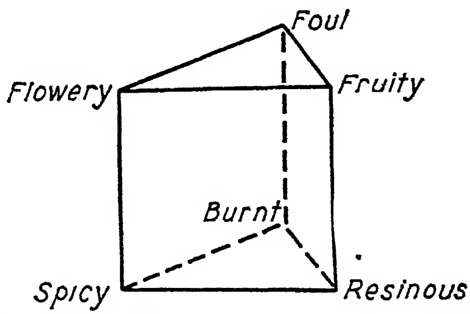


FIG 31—Smell prism. A scheme for classifying odors on the basis of their similarity and difference These are the six main types of odor Intermediate odors need not be considered as "blends" of the odors at the corners but may be elementary sensations located at suitable points on the surfaces of the figure. After H Henning, *Zeitschft f. Psychol*, 1915, vol. 73, p. 254.

a gas pipe is an instance of a law found in the laboratory: almost all odors grow faint or become imperceptible within a few seconds or minutes. Most of this is due to action within the sense organs themselves. These sense organs are scattered about the mucous membranes of the interior of the nose, the membranes folding in and out in such a way as to expose a large surface (several square centimeters) to the inhaled air

A large part of what is called taste is simply smell. Stuffing the nose with cotton, or merely holding it clothespin fashion, will make unsuspecting and untrained observers mistake cod-liver oil and oil of wintergreen, or tea and coffee. Learning how to swallow at the right time and other similar devices will spoil

the experiment, since ordinarily, of course, a good deal of the odor is communicated "up the back way" To conduct the experiment under ideal conditions, no air should pass up behind to the nasal surfaces. Persons who have lost the sense of smell lose most of their satisfaction from food; even a cold may have the same effect, although this does not usually affect the sense of taste.

FIG 32.—Section through the taste-bud of a rabbit This was prepared for the microscope so that the sensory cells are shown in black. From G. H Parker and W. J. Crozier, in C. Murchison (ed), *The Foundations of Experimental Psychology,* Clark University Press, p 368 By courtesy of the publishers

There are four fundamental taste experiences —*sweet, sour, bitter, salty.* The tip, sides and back of the tongue are equipped with large numbers of little pits, or "papillæ," within which are to be found "taste buds" (cf. Fig. 32). Within the buds are the taste cells, the arousal of which by substances in solution sets going the taste impulses in the sensory nerves The four fundamental taste qualities which have been experimentally established are dependent upon specialized taste cells. Those for salty. are scattered; those in the tip of the tongue are mostly responsive to sweet, those on the sides to sour, and those on the back to bitter (there are also some taste cells in other parts of the back of the mouth). There do not seem to be any tastes other than these four. Most of what we call taste is smell or touch or warmth or cold, so that apparent tastes are greatly changed by factors which influence all these other sensory qualities. Just as smell profoundly affects the apparent taste of a substance—making the difference between apples and onions, which cannot be distinguished by their taste alone—so taste itself is affected by what comes down the air passages of the nose. Not only do some substances (e g, ammonia) stimulate the nasal membranes in such a way as to give rise to experiences which are not strictly those of smell, but other substances (e.g., chloroform) are swept down by air currents to the back of the mouth and there stimulate taste cells. The subject gives a different report of the odor, depending upon whether the taste cells are aroused or not.

The modern brain evolved from a "nose brain."—The sense of smell is very old in the history of the race. The "modern brain" appeared in evolution first as a "nose brain," a center for smell; and the human brain still shows this older part embedded within the new; note the cross-hatching in Fig. 33 It is interesting to see how little progress has been made along these lines in the last million years or so. Bees which habitually respond to particular odors show a capacity for discrimination much like our own and, in fact, seem to confuse the same stimuli we should

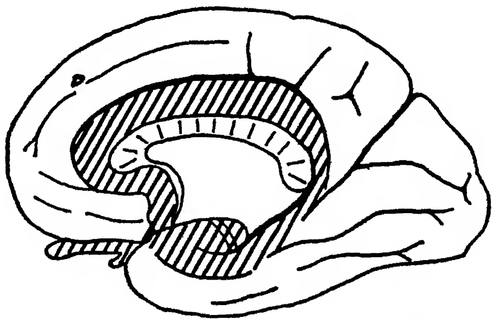


FIG. 33 —Section through the human brain. The "forehead" end is at the left. The heavy cross-hatching shows the "nose brain" This part of the brain developed very early in the evolution of the modern brain and varies but slightly (in structure and function) through a wide range in the animal kingdom.

confuse—as if for the bee the odor qualities were quite similar to those which we experience. Dogs are considered to be superior to human beings not only in smell *discrimination* but in the *detection* of all kinds of faint odors It has sometimes been suggested that civilization, with its soft-pedaling of the "lower" senses and its elaborate cultivation of sight and hearing, has actually weakened the sense of smell, but experimental study of primitive man as compared with civilized man seems to show no difference in actual smell sensitiveness. It seems more likely that the stock to which we belong did not have to develop this sense to such an extraordinary degree because its mode of life made it more dependent upon hearing, and in particular upon

seeing, which, as we have noted, is as highly developed in man as anywhere in nature.

One might say, then, that the "modern" brain of all species higher than fishes got its start through specializing in sensitive discrimination among chemical sources of stimulation It must be added that as soon as the modern brain evolved, old functions which were located in the brain stem "migrated forward" and took up their site in the new brain. But the old centers remain, too. Thus we have a reflex center for the eyes in two little bodies which lie near the thalamus, although the center of conscious visual activity, i e., seeing, is in the cerebral hemispheres. In the same way the old reflex centers for response to sound remain in bodies adjacent to the thalamus, while the center for hearing has moved forward. The olfactory lobe, however, has stayed exactly where it was. In other words, sight and hearing have undergone specialized development along with the development of the brain itself, while the older, more primitive brain arrangement remains sufficient for the sense of smell.

SUMMARY

Sense organs contain cells which are specialized to receive particular kinds of physical energy—light, sound, etc. The intensity of sensation depends on (a) number of impulses per second along the nerve fiber, (b) number of fibers involved The quality of sensation depends on the nature of the response in the brain The simpler senses include the skin senses, warmth, cold, touch and pain; organic sensations, kinæsthetic sensations, giving awareness of position and movement of the striped muscles; and the chemical senses of taste and smell The whole "modern brain" has been built up on a nucleus which far back in the evolutionary series was just a "nose brain."

REFERENCES

Adrian, E D , *The Basis of Sensation*, 1928.
Hollingworth, H L , and Poffenberger, A. T , *The Sense of Taste*, 1917
Mach, E , *The Analysis of Sensations*, 1886
Murchison, C. (Ed.), *Handbook of General Experimental Psychology*, 1934, Chapter XIX, by W. J. Crozier; Chapter XX, by J. P. Nafe.

PROBLEMS

1. Why does the coldness of cold water seem spread out over the body instead of concentrated in small spots?
2. Can tastes be made to "fuse" as warmth and cold fuse in heat?
3. A French author suggests that our belief in a world of solid "matter" is due largely to the resistance offered by objects to our muscular movements What do you think of this?

CHAPTER VIII

HEARING

HEARING, as we have said, is related to touch. In the history of the race it has developed from the sense of touch or "contact sense." A bat can fly through a pitch-dark room in which horizontal wires have been strung, avoiding the wires by catching the echoes of the air vibrations Hearing is really a more refined way of feeling through the contact sense Deaf people enjoy the rhythms of music as if they actually heard it, and persons with normal hearing sometimes actually mistake a slight rhythmical reverberation in the floor for a rumbling sound, under conditions which make real hearing absolutely impossible

Nevertheless, the sense of hearing is so much more complicated than the sense of touch that it must be treated as something distinct. In order to have true hearing, there must be a particular kind of excitement set up in certain parts of the ear which are not visible from outside We shall consider first the nature of the disturbances in the air which give rise to hearing, and then the nature of the internal changes.

Air disturbances may be rhythmical, in which case they give rise to "tone"; or non-rhythmical, in which case we call the result "noise." Rhythm or pulsation must be as rapid as fifteen or twenty vibrations per second to be heard as a tone If a tuning fork with very long arms is used, vibrating only eight times a second, we may watch its movement and hear nothing As it gets to twelve or fifteen vibrations a second, an indefinite low rumbling or murmuring is heard, and at about fifteen to twenty vibrations per second we actually hear a very low tone. At the upper limit the shrill sound of a whistle fades out into a sort of whispering or puffing sound, and finally becomes inaudible

at about twenty-five thousand vibrations per second (more or less, depending on the individual).

Individual differences in sensitiveness to intensity of sound are very great Judging by the distance at which we can hear noises and tones of various sorts (such as the ticking of a watch, low whispering, the purring of a motor, etc.), the average person's hearing is fifteen or twenty times as good as it needs to be in order to get along passably in most situations. When a speaker's voice is not forced to compete against the sounds which a restless audience makes, conversational tone can usually be heard at from two hundred to three hundred feet. Many individuals are completely deaf in one ear and partially deaf in the other without knowing more than that they have a good ear and a bad ear. Occasionally a true case of absolute "tone deafness" is found in which individuals can really hear tones of ordinary intensity yet cannot tell one pitch from another, while other individuals can instantly tell the pitch of an isolated tone (this ability is called "absolute pitch")

Sound waves are waves of condensation and rarefaction of air particles.—We may think of every resounding body, including the vocal cords, as giving the air a certain kind of blow. As the blow is delivered to the air, the air tightens or condenses at the point where it is struck, just as any elastic body must tighten or condense when one presses on it. As soon as the force of the blow is spent, this condensed air thins itself out again or rarefies itself. In the meantime the pressure has been passed on to the adjacent air, so that the point of condensation moves rapidly away. A wave of condensation moves at a constant speed away from the resounding body which started it A brief expanse of rarefied air follows the point of condensation, and then comes another point of condensation which arose as the second blow was given Thus, as the resounding body gives a series of blows, waves of condensation and rarefaction pass out and away in all directions This is somewhat like the crests and troughs of water waves which pass out after a stone is thrown into the water; but in order to get an idea of an air disturbance resulting from

a resounding body, one must think of the stones as being plunged into the water at an even rhythmical rate, each one starting a new wave

Since the speed of air waves is approximately constant at ordinary temperatures and altitudes, it is easy to measure the length of the air wave by counting the number of waves, or vibrations, that are given off in each second; thus, since the

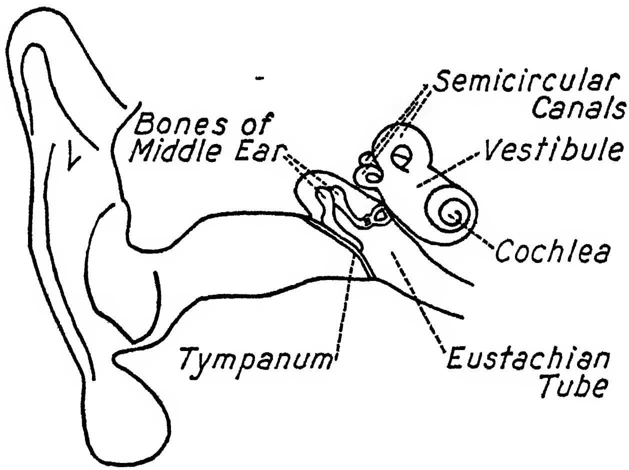


FIG. 34a.—The ear. Sound waves are directed by the external ear against the eardrum (tympanum) The vibration of this membrane sets in motion the bones of the middle ear (see Fig 34b) These transmit the vibration to the cochlear fluid, stimulating the receptors (see Fig 34c) The semicircular canals and the vestibule are important in maintaining equilibrium, cf page 175

speed of sound is about 1100 feet per second, middle C which has 256 vibrations per second represents air waves about four feet long. Long before the details of the modern science of tone were discovered, the builders of organs had of course learned by careful experimentation how long to make organ pipes to provide each pitch

The sound waves from a vibrating body are caught and funneled by the external ear, and set going vibrations in the eardrum or tympanum; see Fig 34a. The eardrum communicates the vibration in sequence to three little bones: hammer, anvil and

stirrup in the *middle* ear (see Fig. 34b), which magnify it and deliver it at an organ of the *inner* ear called the cochlea. The cochlea looks something like a snail shell, being large at one end,

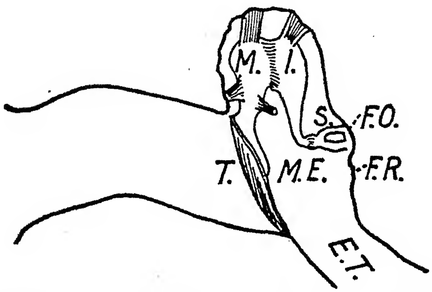


FIG. 34b.—The bones of the middle ear. These bones transmit the vibration of the eardrum (tympanum, *T*) to the fluid of the cochlea. The bones are the hammer (*M*), the anvil (*I*), and the stirrup (*S*). *F.O.* and *F.R.* connect with the inner ear. *E.T.*, the Eustachian tube, connects the middle ear (*M.E.*) with the throat. After J. D. Lickley, *The Nervous System,* 2nd ed., Longmans, Green, and Co., p. 116. By courtesy of the publishers and the author.

small at the other, and making nearly three complete "turns." The liquid within it is set into vibration by the vibrations in the bones of the middle ear. This liquid stimulates the *basilar mem-*

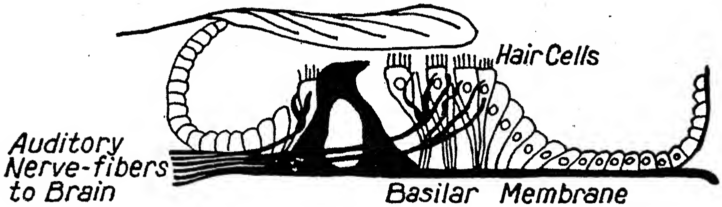


FIG. 34c.—Section through the organ of Corti, the receptor organ for hearing. The mechanical action of the bones of the middle ear serves to transmit vibrations to the cochlea. Wound about in the cochlea in the inner ear is the basilar membrane. The vibrations of the fluid in the cochlea cause different parts of this membrane to respond by vibrating. These vibrations of the basilar membrane pull on the hair cells and stimulate the nerve endings in them. These are the impulses which finally go on to the brain and which provide the basis of our auditory experiences.

brane. Different parts of the basilar membrane have low thresholds for different vibration rates. The vibration rate which will set one part of the basilar membrane vibrating may not be

able to excite another part The motion of the basilar membrane appears to cause mechanical distortion of the nearby *hair cells*, seen in Fig 34c. In the hair cells the impulses start along the nerve fibers to the brain. Thousands of nerve fibers may be seen as they emerge from the inner ear, making their way to the hearing centers in the temporal lobes of the brain not far from the temples (compare Fig. 58, page 200). Most of the fibers from the right ear cross to the left temporal lobe, and *vice versa.*

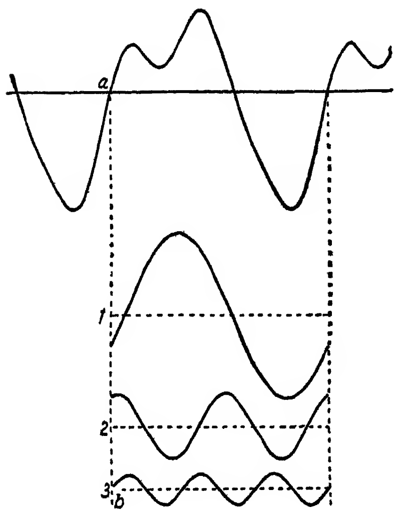


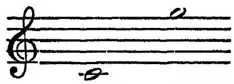
FIG 35 —Analysis of a sound wave produced by a violin The upper wave is the record of the vibration produced by the violin Analysis shows this curve to be composed of the three vibration rates represented below it When measured on lines parallel to *ab*, the altitude of the composite curve is the algebraic sum of the deviations of curves 1, 2, and 3 from their lines of reference (the dotted horizontal lines) From D. C Miller, *The Science of Musical Sounds,* Macmillan Co, p 103 By courtesy of the publishers and the author

The (a) amplitude, (b) frequency, and (c) form of air waves give rise respectively to (A) intensity, (B) pitch, and (C) timbre.—The *intensity* of a tone depends upon the amplitude of the air wave, the actual amount of commotion in the air; *pitch* is determined by the frequency, or wave length. The quality, or *timbre*, of tone —the difference between the tone of violin, piano, flute, etc, at a given pitch and intensity—depends upon differences in form or combined effect of various wave lengths. Every sound has a fundamental tone, the lowest tone which a given resounding body produces Almost every resounding body, however, gives off simultaneously various more rapid vibrations, or *overtones*, so that the same object may produce simultaneously *several* pitches Thus in Fig 35 the different lines indicate

different vibration rates coming from the violin at a given time. In the top line *a*, there is a representation of the actual amount of condensation and rarefaction of the air during the time interval it was studied. The heavy horizontal line indicates quiet air and is a sort of zero point, or point of reference The condensation of air is indicated by the altitude of each point on the curved line above the base line, while rarefaction is indicated by the curve below the base line. Thus, beginning at point *a*, we have rapid condensation followed by a small amount of relative thinning out, then rapid condensation working up to a maximum, then rapid and steady rarefaction until the lowest point on the curve is reached, then the rapid return to the base line and the repetition of the whole cycle. The way in which this component curve is derived for fundamental and overtones is easy to understand if one notes lines *1*, *2* and *3* which are drawn below the line *a*. It will be seen that in addition to the fundamental tone indicated by *1*, there is another tone given off which is the result of vibration at double the rate of the fundamental tone, as shown in *2*; while *3* represents a vibration which is three times as rapid as that shown in *1*. Each of these numbers, *1*, *2*, and *3*, shows the actual amount of condensation and rarefaction measured at a given time The effect produced may be added up if there are two disturbances in the same direction, and one may be subtracted from the other if they work in opposite directions. The actual amount of condensation or rarefaction of air can be properly shown by simply combining the effects of all three curves If two condensations actually coincide, there will be all the more condensation. If a given place is a sort of meeting place of two rarefactions, the air will be all the more thinned out. If a condensation takes place as the result of one vibration at a given point and if a rarefaction occurs at the same point as the result of another vibration rate, the air may be neither condensed nor rarefied, just as if nothing were happening.

Timbre may be illustrated just as well by referring to any other musical instrument. An organ pipe whose fundamental tone is 256 vibrations, that is, middle C, also gives off some vibra-

tions of twice this rate. Though resounding as a whole, even the most carefully prepared material tends also to vibrate in parts Though the organ pipe resounds with the whole length of its air column at a certain pitch (because it takes the air a certain length of time to send a pulsation down and back the length of the pipe), it also tends to shake, so to speak, in halves, just as the violin string, if closely watched, may be seen to shake in halves when it is very lightly bowed. The effect of making the pipe or the string vibrate in "halves" is to produce a tone an octave higher. Let the rate of vibration be three times that of the fundamental and one has a "musical fifth" of the second octave above the fundamental (the *sol* of the octave above the next *do*).



Most instruments give off several overtones; some give off as many as twenty. Some of the high tones of the bass viol, for example, cannot be distinguished from tones given off by the oboe if one has "filtered out" by mechanical devices most of the overtones of each instrument. But if, say, only fourteen of the overtones of each are filtered out, the few remaining ones, though we never notice them independently, are still enough to give the two instruments characteristically different tone qualities What seems to be psychologically a strictly unitary thing—the pure tone of the instrument—is physically a composite To remove all doubt that this analytical notion of the nature of sound is correct, Helmholtz actually built up, by means of tuning forks and small metal resonators, tones which seemed to his observers to be those given off by pianos, violins, flutes, and the rest

The relative intensity of overtones is just as important as their number.—Some tones such as those of stringed instruments are characteristically rich in the higher overtones They have, of course, the lower overtones too, as all instrumental and vocal tones do, but the effect of these is rather drowned out by the

higher ones. Even if two instruments have exactly the same overtones, they can be easily distinguished if they differ in the relative prominence of the overtones; in fact, the characteristic differences between most musical instruments are due to the relative prominence of certain of the overtones. The same is true of the difference between different tenor voices, etc.

The quality of a musical instrument, however, and of the voice in particular, is affected by other things besides the overtones. Skillful singers show rhythmic throbbings or pulsations in intensity as well as rapid oscillations in pitch. Some of these latter indeed are unintentional—a very skillful singer does well if he or she can keep the pitch within five vibrations per second of the pitch intended But slight variations up and down in pitch and slight variations in intensity are usually desired for variety and richness. The reader has doubtless noticed how the violinist for the most part avoids playing on an "open" string He can get the same pitch by playing the same note on a lower string, applying his fingers so as to shorten it, and allowing the finger to pulsate rapidly so as to give the traditional "human" sound which distinguishes the violin from many other instruments which cannot be controlled in this way.

Thus, good tone is really a complicated thing, involving patterns in time as well as in space. The study of all these properties of the voice and of musical instruments has been greatly aided by the recent perfecting of instruments which turn the sound wave into a permanent visual record. The ups and downs in pitch may be electrically recorded and converted into actual ups and downs on a photographic plate. In fact, one uses the phrase "photographing the voice" to describe studies of this sort.

Localization of sound depends chiefly on relative intensity at the two ears.—To test capacity to localize sound, an experiment makes use of clicks given off by an instrument which can be moved about. As a source of sound is moved around the horizontal framework or up and down along the meridians, the relative intensity of the sound as received by the two ears is made to vary and the blindfolded subject gives his report as to

the apparent source of the sound. When single clicks are given, it is found that the variation in position to left or right permits very sensitive discrimination. But an object may be judged to be high when it is low, or behind when it is in front.

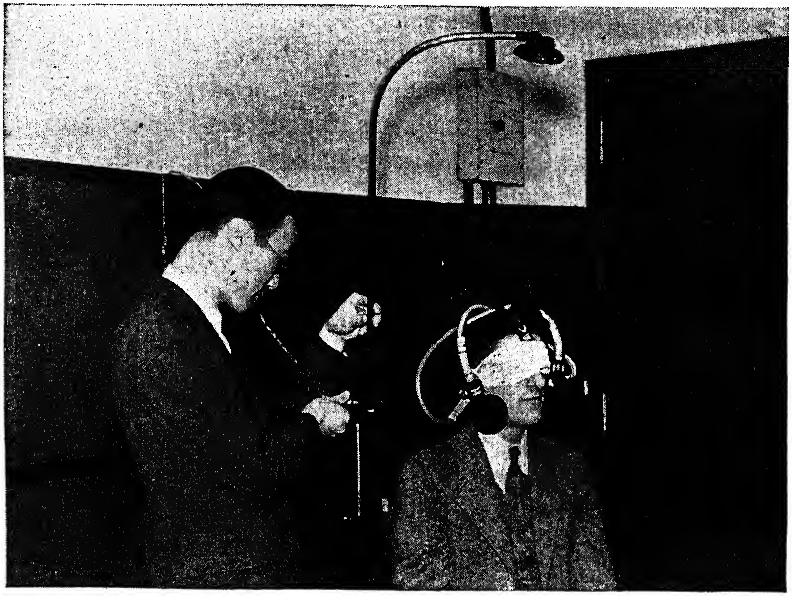


FIG. 36.—Apparatus for studying the ability to localize sounds. An electrically produced click can be made in the cup at the top of the curved rod. By means of the swivel which he is adjusting, the experimenter may, without moving, make the stimulus come to the subject from almost any direction. The blindfolded subject must point to the source of the sound and the experimenter calculates his error. This error will vary depending on the point where the click is really made.

In this figure, the subject is wearing a pair of pseudophones (invented by P. T. Young). Note how the tubes lead from the receiver on one side of the head to the ear plug on the opposite side. This results in a general reversal of localizations of sounds from the right and left, though it does not affect the perception of the true position of sounds in the median plane.

The apparent source of sound may be reversed right and left by having the subject wear the sort of phones shown in Fig. 36. A source of sound seems to be at a point on the other side from the true source because the phones are reversed. But when a sound seems to come from the left and the subject sees the sound-

producing object on the right, the same effect does not come about; under ordinary conditions sight dominates over hearing.

The Helmholtz "resonance theory" of hearing states that the various fibers in the basilar membrane respond by sympathetic vibration to tones of different pitch.—The reader will recall that the inner ear is in a cavity in a bone of the skull which contains a spirally wound tube, the cochlea; the cochlea contains the basilar membrane. The basilar membrane responds by vibrating in various ways in accordance with the vibration imposed upon it by the bones of the middle ear. Among the various theories as to how the basilar membrane works, the one which has enjoyed the greatest favor is the Helmholtz resonance theory, based on the idea of "sympathetic vibration." The principle of sympathetic vibration is illustrated by the fact that when a piano key is held down and one sings the corresponding note the piano wire will give back the tone. This, of course, is because the air between the mouth and the string has set up in the string a vibration corresponding in frequency to that of the voice. It is assumed that the basilar membrane is capable of acting in this same way as a resonator. It is not necessary to assume that only *one* fiber responds sympathetically to a given frequency—probably a *band of fibers* is excited. But the one which is the most vigorously excited is the one tuned to the given tone.

This theory seems at first to be perfectly clear and satisfactory, but it is not as simple and easy as it seems For one thing, the shorter the string, the higher its pitch—compare a bass viol with a violin The longest fibers in the cochlea are only about three times the length of the shortest ones, whereas, in order to account for the wide range of audible pitches, we should expect the longest ones to be many times the length of the shortest Nevertheless, this difficulty seems to be taken care of by the fact that the *loading* and the *tension* vary at different parts of the cochlea A fiber carrying a load is like a tuning fork which is *slowed down* by a piece of wax attached to it On the other hand, greater tension would *raise* the vibration rate just as it does in the case of a

rubber band. Varying loads and tensions probably permit an extraordinary variation in sensitiveness to pitch among the fibers of the basilar membrane. It is possible that the basilar membrane can do what the theory requires of it It is true that a single fiber cannot send 18,000 or 20,000 impulses per second to correspond to a tone of that pitch, but modern versions of the resonance theory do not require this. The fourteen or fifteen thousand fibers which run from the basilar membrane to the brain are probably adequate to report the differences in pitch which we can distinguish. The *intensities* of the different tones are perceived by virtue of the *different frequency rates along the different fibers* in accordance with the Adrian principle (page 116), but it is necessary to think of this principle as applying to many nerve fibers acting at once. The reader will recall that the intensity of the sensation depends on the frequency rate of the nerve excitement.

This account is too simple to do justice to all the theoretical and experimental work which is now going on in relation to the resonance theory. Though the evidence given makes it probable that instead of thinking of individual fibers as the basis for perceiving individual tones we ought to think of *groups of fibers* as working together to give the necessary basis for each tone, the experimental work is too complicated to be discussed and criticized here. The foregoing simplified account is probably roughly correct as far as it goes. Intensity probably depends on the Adrian principle, and response to pitch probably depends on the fact that different fibers in the basilar membrane have thresholds specially low for different pitches. Timbre would then be explained on the assumption that many pitches, each at a given intensity, can be responded to at once.

SUMMARY

The amplitude of sound waves determines intensity or loudness; the wave length determines pitch The form of the wave determines timbre. The form is the way in which fundamental

and overtones are combined The localization of sound depends chiefly on relative intensity at the two ears. The basilar membrane in the inner ear, when responding to all these characteristics of the sound wave, sets going the nerve impulses to the brain which result in hearing Though the theory is incomplete, there is some truth in the "Helmholtz resonance theory," which states that parts of the basilar membrane respond sympathetically to the different wave lengths, thus yielding sensations of pitch. Loudness seems to depend upon the number of impulses per second along the nerve fibers. In order to perceive timbre, it is necessary to respond both to differences in pitch and to the different intensities of the different tones.

REFERENCES

Fletcher, H, *Speech and Hearing*, 1929.
Helmholtz, H L F von, *The Sensations of Tone*, 1869.
Herrick, C. J., *Introduction to Neurology* (5th ed), 1931, Chapter XIII
Miller, D. C, *The Science of Musical Sounds*, 1916.
Ogden, R. M., *Hearing*, 1924.

PROBLEMS

1. Outline the characteristics of a world in which we could hear the vibrations above our present hearing threshold limits, but could not hear what is now within our range. What details of our daily life as we now live it would be grossly different?
2. How do you recognize the voices of different people over the telephone? How can a bad cold make a voice unrecognizable?
3. What makes for "good tone" in a violin?
4. What do we really do when we "train the ear" as part of a musical education?

CHAPTER IX

SIGHT

THE characteristics of what we see depend first of all on the physical characteristics of the light wave. Light waves are transverse; the wave motion is perpendicular to the line of flight from the luminous object. They are similar to the sidewise undulations of a long rope as one end is snapped while the other end is held to a wall. Or they are like the *sidewise* movements of a fish's tail as contrasted with its *forward* movement through the water. These waves vary in *wave length*, measuring from crest to crest, though waves of different length are usually mixed together. Waves differ also in their *energy*.

Light waves are brought to a focus on the retina.—Light waves pass from the cornea (compare Fig. 37) through the various parts of the eye, being refracted or bent from their original direction. The lens bends the rays in such a way that an image is brought to focus on the *retina*, or inner lining of the eyeball. The retina contains the sense organs for sight Near the center of the retina is a small spot, called the fovea, which gives by far the best vision; focusing on the spot gives clear vision. Vision is less clear as we proceed out from the fovea

Using the term "form" in the geometrical sense, we find that visual perception is often formless in the outer zone of the retina As an object is moved from this outer zone inwards, it passes through a fuzzy semi-formed stage and only in the end achieves definite "form." In the language of one recent study, the object moving from the outer zone of the retina to the fovea passes through four stages: "figureless field; formless figure; form-like figure; clear figure." This result is chiefly due to the structure of the eye, the retina in this case becoming more and more capable of clear reporting as we move toward the fovea. This region of

clear vision is really very small. As we carry on a conversation, we think we see the person before us clearly at each instant, but the eye constantly shifts from one point to another. We may even

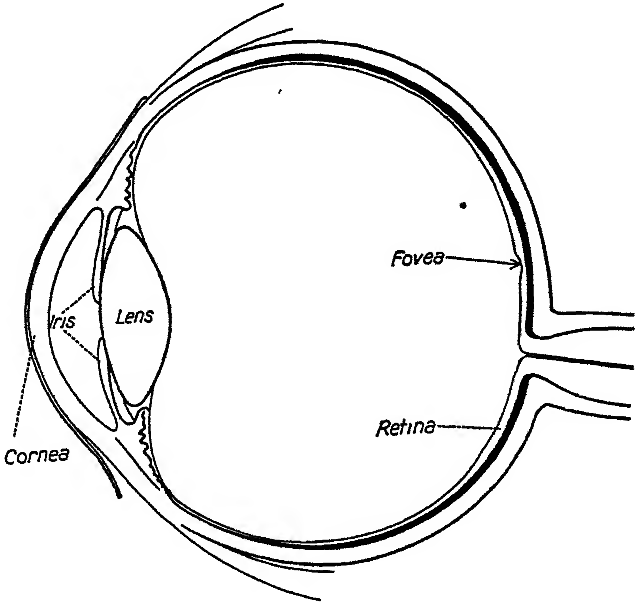


FIG. 37.—Cross-section through the human eye. The lens, by changes in its thickness, focuses the light rays on the retina, the light-sensitive tissue of the eye The fovea is the region of clearest vision. The area where the nerve fibers from the retina join to enter the optic nerve, which branches off at the right of the figure, is the so-called "blind spot", cf p 146.

glance over a landscape with the impression that we see it all clearly, though at any given instant only a small region can be clearly fixated.

FIG. 38.—For discovery of the blind spot

As the fovea is the point of clearest vision, so the spot where the optic nerve meets the retina is the point of the least clear vision within the whole central part of the retina; it is called the

"blind spot." Fixate the black cross with the right eye, closing the left eye, and move the book about sideways at a distance of twelve inches till the circle disappears.

The blind spot is not, however, absolutely blind. Light thrown upon it can be seen and distinguished from lights surrounding it; and though it distorts form, it can make some form discrimination Cf. Fig. 39.

We have been describing the eye when adapted to light In a dark room changes occur The most obvious is the rapid dilation

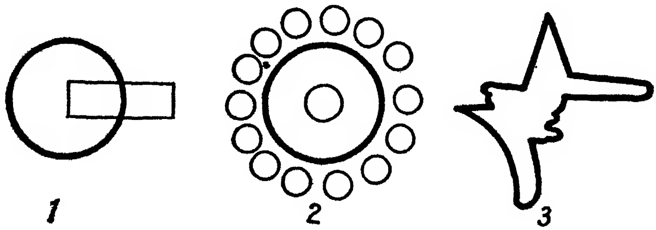


FIG. 39.—The effect of direct stimulation of the blind spot In 1 and 2, the blind spot is represented by the heavy black circle although the blind spot itself has no such regular form When, as in 1, the stimulus fell partly within the blind spot, the spot was stimulated to some extent When the stimulation was as in 2, observers reported that between the outermost edge of the halo of light within the blind spot and the circle of lights surrounding it, there was a dark space with no light A cross exposed completely within the blind spot was called a cross, but its form was distorted as shown in 3 This is some of the evidence that the blind spot is not completely blind From H Helson, *Amer J Psychol*, 1929, vol 41, p 372 and p 387. By courtesy of the editor and the author.

of the pupil, which within one minute may become several times as large as it is in the bright sunlight. However, the most interesting changes, from a psychological point of view, do not occur for some time. Full dark adaptation takes effect in a half-hour or an hour. It is in large part a matter of the chemistry of the retina, and of the kinds of sense organs in the retina which are being called into play. The light-adapted eye sees by means of very small cone-shaped sense organs packed close to the central spot or pit of the retina, and gradually thinning out in all directions from it Microscopic analysis shows these cones to be connected (by other cells) with the fibers of the optic nerve. As the

cones become more scarce toward the edges of the retina, however, another type of structure becomes more and more numerous —rodlike structures, likewise connected with the optic nerve. The rods are functionally unimportant in the light-adapted eye. As darkness comes on, they are responsible for a larger and larger share of work, and there is evidence that they do all the work that is done by the eyes under complete dark adaptation On a starlight night when the moon is not up, the effectiveness of rod vision can easily be tested by glancing about among a group of faint stars. Out of the corner of the eye one sees a faint star to which one tries to give close attention If the eyeball is turned so that one looks directly at the star, it will *disappear.* The same experiment is easily carried out in the laboratory with a circle of small dots like the ring shown in Fig. 39, No. 2. One allows the eyes in a darkened room to move rapidly about the circle of dots. The dots will seem to chase one another, since the eye will see the dot which was sought a moment before, but never the one toward which the eye is directed at the moment

There is evidence to suggest that the rods are the older and more primitive sense organs of the retina Color is, so to speak, a special luxury imported into the world of vision of some of the higher species, making possible better discrimination and more effective adjustment than was possible with rod vision, which lacks both color and brightness response.

(a) Wave length, (b) amplitude, and (c) purity are the chief factors in producing (A) color or hue, (B) brightness, (C) saturation.—When the eye is adapted to light, optical impressions have a certain *color*, a certain *brightness*, and a certain *saturation*. The terms color and brightness are used in psychology as they are in everyday speech; the term saturation refers to the fullness or purity of the color, i e., its freedom from mixture with white, gray or black. Thus a sky blue is much more saturated than a light blue (tint) or very dark blue (shade).

The *color* depends primarily upon the *length* of the wave, measuring from crest to crest; this becomes shorter as we increase the number of waves within a given distance. Measuring "along

the ray," the more waves there are per millimeter, the shorter they are; thus red, having a very long wave length, has fewer waves per millimeter than violet has. The *brightness* of the objects

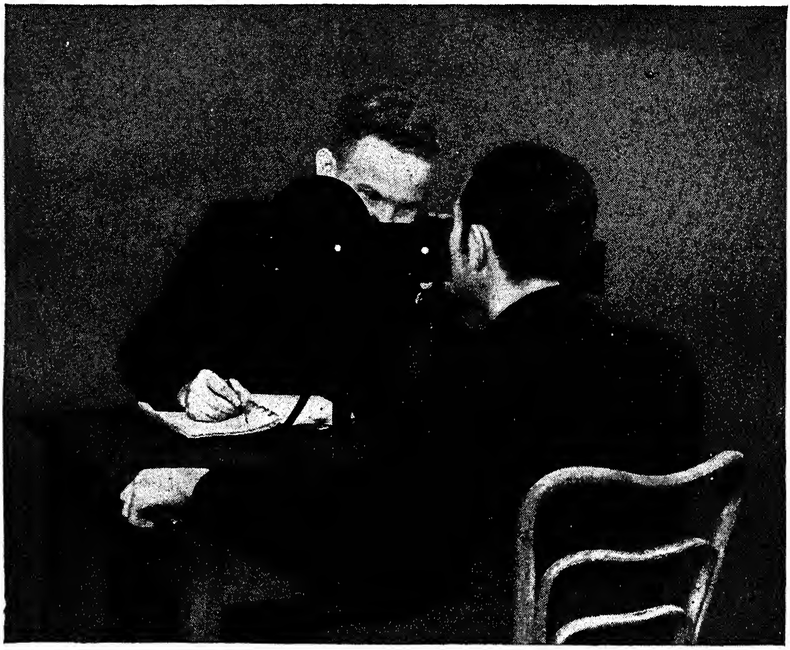


FIG. 40.—Perimeter, apparatus for measuring the sensitivity of different parts of the retina. One eye is studied at a time. The subject keeps the eye from moving by focusing it on a point directly in front of him, the left spot. The experimenter moves a colored object along the graduated arc of the instrument and records where the object is when the subject announces the colors he perceives. A red object being moved in toward the center may be reported first gray, then yellow, and finally red. The stimulus is generally moved slowly toward and away from the center several times and an average taken of the positions where it can be correctly responded to. The frame of the apparatus is movable and all parts of the retina can be studied. Maps of the sensitivity of the retina so obtained have been important in the framing of color theories.

seen depends primarily upon the *energy* of the slashing movements, to and fro, which are made as the light wave comes toward one. The *saturation* depends on the *purity* of the light wave; if the waves entering the eye all have the same wave length, we have a pure or saturated color. If they are a jumble of many wave

lengths, we have a "tint" or a "shade," the nature of which is determined by the waves which are predominant in the mixture. We shall first describe the simpler facts of color vision and then discuss the theories to explain them.

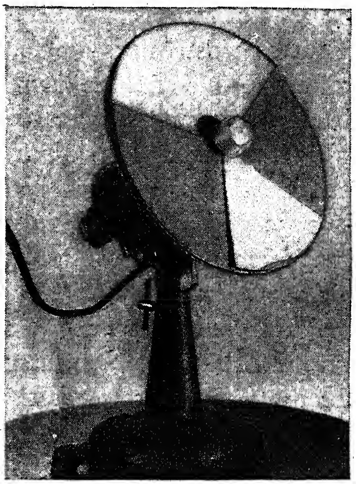


FIG. 41.—Color wheel. Colored (or otherwise marked) cardboard disks, so slit that they can be fitted together and overlap, presenting variable amounts of surface in the whole 360 degrees. Here four disks, colored with different brightnesses of red, green, blue, and yellow, are mounted. The speed at which the wheel rotates can also be regulated. The wheel offers a controlled means of presenting stimuli in investigating the phenomena of color and of brightness vision.

We are so thoroughly accustomed to perceive in terms of color and form that one is surprised in the laboratory to discover that under ordinary illumination most of the retina does not know one color from another and cannot clearly distinguish form. If we fixate a point directly in front of us and if other objects are moved about nearby, we find that the latter vary greatly in hue and sharpness of outline.

The region in which colors and form are well discriminated, as in normal life, represents only a small central zone. The more or less circular region where all colors are distinguished (and within which lies the fovea) is surrounded by another zone in which blues and yellows are fairly well distinguished and retain their usual appearance; this region extends through twenty or twenty-five degrees. The entire outer zone of the retina is for the most part merely a receiving station for gray. The method of mapping these regions is shown in Fig. 40. All these generalizations, however, which hold under ordinary conditions, have to be modified if the intensity of the light is great; in this case nearly all colors can be seen. The color zones, moreover, are not marked off by absolutely sharp lines.

There are several simple ways of neutralizing colors, that is, of making their color quality lose itself in gray. Different colored lights from two or more sources may be made to shine upon the same spot in the retina, or cardboard sectors may be rotated on a color wheel (Fig. 41) so rapidly that they mix By these methods most colors are found to have "complementaries," i.e., colors which neutralize them and give gray. For every color at the left of the spectrum there is a color at the right of the spectrum which when mixed with it will yield gray; but colors in the middle of the spectrum (greens) have no such complementaries A pure yellow is complementary to a pure blue; a dull red is complementary to a bluish green. Some of the complementaries are named in Fig. 42.

After one gazes steadily at a color and glances quickly at a gray field the complementary color appears; this is a "negative after-image." Most readers will remember blue or purple after-images from gazing at the yellow sun, but even a stimulus so weak as not to be perceived at all may at times produce a negative after-image which can be seen

Next come the phenomena of color contrast. If one looks fixedly at a green square on a gray field, in twenty or thirty seconds there will appear a reddish border about the square Similarly, gazing hard at a blue square will induce a yellow border The contrast color is thus the same as the after-image color, at least approximately so.

If one rotates upon a color wheel sectors of orange and blue, or of red, yellow, and blue; or of red, orange, yellow, green, blue, violet, and so forth, he can, with a little adjustment, show that white light (and any of the grays) is made of a mixture of wave lengths. If one pursues these experiments further, he finds that the objects which we ordinarily call white and gray are usually objects which reflect back to us all the wave lengths of the sun. If any color at the right of the spectrum is combined with a color at the left of the spectrum, the result is to reduce the saturation Part of each color may be thought of as neutralizing part of the other to give gray. This gray, mixed with the pure

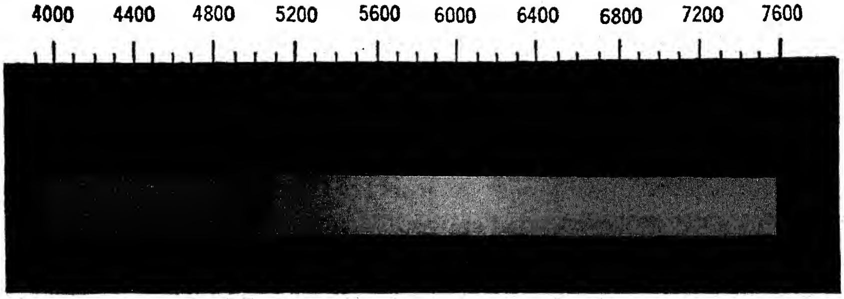


FIG. 42.—The spectrum. (From Duncan's *Astronomy*, published by Harper & Brothers.)

Color		*Complementary color*	
Red	6562	Green-blue	4921
Orange	6077	Blue	4897
Golden yellow	5853	Blue	4854
Golden yellow	5739	Blue	4821
Yellow	5671	Indigo-blue	4645
Yellow	5644	Indigo-blue	4618
Green-yellow	5636	Violet	below 4330

The numbers refer to the scale at the top of the plate, representing the wave lengths. That there are several wave lengths given the same color name is due to the fact that the colors of the spectrum really imperceptibly fade into one another; and a wide band, a large range of wave lengths, may be designated by a single color-name.

Violet includes 3900-4220, best represented by 4100
Blue includes 4220-4920, best represented by 4700
Green includes 4920-5350, best represented by 5200
Yellow includes 5350-5860, best represented by 5800
Orange includes 5860-6470, best represented by 6000
Red includes from 6470 to the limit of the visible spectrum, best represented by 6500

color left over, gives an unsaturated color. Mixture with a light gray gives a tint, with a dark gray, a shade.

Children of three or four respond rather consistently to certain colors; for example, they show "color preferences." Many investigators are agreed that there are definite age and sex differences in such preferences We have not explored these facts fully, but enough has been done to show that the little child does see color in the sense that he responds consistently, noting a real

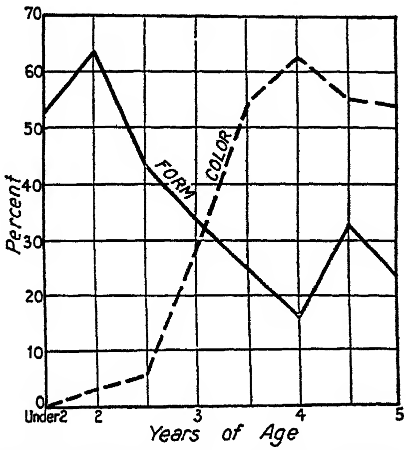


FIG. 43 —Relative importance of form and color at different ages In a situation where an object was presented so that it might be matched either with another of the same form or with another of the same color, younger children tended to select on the basis of form, older, on the basis of color. The curve shows the percentage of those tested at each age who responded consistently on one basis or the other (a necessary correction being made for their different ways of working) From C R. Brian and F L Goodenough, *J. Exper. Psychol*, 1929, vol 12, p 210 By courtesy of the editor and the authors

resemblance between the various things we call blue, a resemblance between the various things we call red, etc., and learns to apply these terms, as we say, "appropriately." Colors have usually become matters of intense interest by three or four years of age, and the four-year-old usually has at least four or five color names which are consistently used Compare Fig. 43

How far does this color discrimination or color differentiation go? Within the spectrum of the sun, adults can distinguish a

hundred hues or more; proceeding from the red end of the spectrum (or the red rim of the rainbow as magnified for experimental study), an adult can find that number of "transition" points where he reports the color changing. Some adults can carry out studies of this sort effectively in the yellow and blue parts of the spectrum, but not in the red and green These are "red-green color-blind" persons. (The condition is rather common in men, probably three or four out of a hundred having some degree of red-green color blindness, while it is rather rare in women; there is a good deal of evidence that it is a "sex-linked" hereditary trait.) Curiously enough, red and green are the same colors which were first lost in the color-zone experiment as we moved the stimulus from the center toward the edge of the field of vision (Fig 40). It has been suggested that the central zone of the eye of a red-green color-blind person is like the middle zone of the retina of a normal person, in which only blues, yellows, black and white are seen Recently the attempt to differentiate sharply between normal and "red-green color-blind" persons has had to be abandoned because of the discovery that there are many kinds and degrees of color blindness, particularly in respect to the differentiation among the reds and between the reds and oranges; e g, a person may be red-blind without being green-blind Greatly improved methods of optical examination make it possible to detect differences in perception of color even when a person has characteristically used the "right names" for colors seen. Thus the Ishihara test presents a mosaic of tiny colored circles which form themselves into patterns such as letters, figures, etc, the actual figure depending upon the sensitiveness of the retina For example, a person with normal color vision will see the number 2 on the chart, while a red-blind person will see a 7.

It is not true that the color-blind eye sees reds as if they were greens, or greens as if they were reds It is possible to get direct testimony on this point from individuals who are color-blind in one eye and not in the other, and their testimony shows that the color-blind eye does not see either red or green in terms of the other, but that it simply *lacks* the green or the red or both The

red-blind person sees green as usual; red is to him one of the yellows For him the spectrum is qualitatively nearly constant at one end. The green-blind person sees the yellow prolonged into the middle of the spectrum Judging by such cases, we should conclude that the person who is blind to both red and green probably sees both of them as yellow. Cases of retinal disease occasionally produce blue-yellow color blindness; and, rarely, all color differentiation may be lost, although perception of light, form, distance, etc., may remain.

The theoretical (and controversial) literature on color vision is as huge as the experimental literature on the same topic, and to reach any decision as to the basic laws underlying the perception of color would necessitate surveying far more experimental facts than a book like this can present. But we have noted some of the facts which must be considered in the construction of a theory of color. No theory has been propounded which students of psychology can accept as completely covering all the facts

The Young-Helmholtz "three-color theory" states that the retina contains three kinds of receptors, each kind specially sensitive to one part of the spectrum.—A theory was proposed over a hundred years ago by Thomas Young, who believed that the retina contained receptors specially sensitive to three different wave lengths: one receptor maximally responsive to red, but also responsive to some extent to other colors; a second receptor responsive to all, but maximally to green; and a third responsive to all, but maximally to blue or violet A first step is to define receptors which would be able, if stimulated, to give *all* varieties of visual experience which we have. The curves in Fig 44 indicate the degrees of responsiveness of each kind of receptor to each wave frequency in the whole spectrum

The theory was sponsored by Helmholtz, and has been, in general, adopted by physicists as adequate for their chief purposes. It is, of course, a physiological theory, with many, but not all, of the requisites for a psychological theory. Among the most important psychological requirements are a theory as to the

psychological *uniqueness of yellow*, which certainly does not seem like a mixture of red and green, and a psychological theory as to *white* which, although resulting from a mixture of all wave lengths, does not seem to be simply the sum of all colors. It is

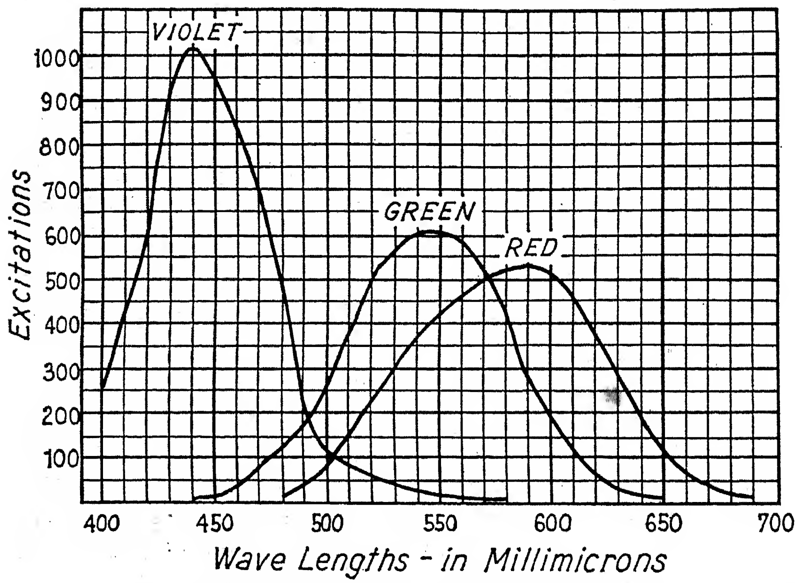


FIG. 44.—Curves showing the amount of excitation of each of the suggested color receptors, when stimulated by different colors. According to the Young-Helmholtz "three-color theory," there are three receptors which account for our ability to distinguish colors. Each of these receptors responds to a wide range of wave lengths (colors) but is especially sensitive to one color; i.e., when we see a color, all three may be active, but one will be the chief factor in the response to the stimulus. The chart shows the extent that each of these receptors is supposed to be excited for the range of wave lengths to which the human eye is sensitive. From L. T. Troland, in C. Murchison (ed.), *The Foundations of Experimental Psychology,* Clark University Press, p. 196. By courtesy of the publishers.

also uncertain whether Young's theory explains the phenomena of color contrast and of after-images. To all these objections, the advocates of the theory reply that all that Young did was to set up a framework which with the necessary experimental supplementation could some time be made to fit the complex facts of vision. His theory was admittedly incomplete, and we still know far too little about optics to be able to explain such complicated things by such a bare and simple formulation. Three-color theories

do, in general, make use of the assumption that the three receptors are those just described—red, green, and blue—but considerable differences in the exact wave length of each of the three can be permitted without destroying the validity of the scheme. There are many different ways in which the three elementaries can be chosen and still give, when mixed, all the possible hues. One quite fundamental difficulty involved in bringing physiological and psychological facts together is the fact that there is nothing in a physical stimulus which tells why a certain thing should be psychologically pure. Most people see orange as a mixture of red and yellow, but spectral orange light can be easily filtered into the eye in such a way that the stimulus is just as pure as would be that of yellow light.

In contrast to the Young-Helmholtz theory, the Hering theory states that three fundamental color receptors serve respectively for (1) red and green, (2) yellow and blue, (3) white and black. Red and green are produced by *opposite types of chemical change in one receptor.* The overworking of the red function caused by staring at a red surface will, upon closing the eyes, cause the reverse chemical change, and a green negative after-image will be seen. So, too, since opposite chemical changes are involved for red and green, the mixture of red and green on a color wheel gives a neutral effect, gray arising from the fact that *all* light affects to some extent the black-white receptor. Blue and yellow bear the same relation as red and green, and white and black are regarded as psychologically just as fundamental as the other four colors; each member of a pair "neutralizes" the other member of that pair.

Among the colors mentioned, black-white, blue-yellow, and red-green are the most interesting. The blue and yellow which yield a gray are at least approximately the same blue and yellow which are seen in the middle zone of the retina after the red and green have been lost, and the same which are retained in the commonest type of color blindness. These are blues and yellows which seem to most observers to be "psychologically pure." They do not seem to be mixtures in the sense in which orange is said to be a mixture of red and yellow. With regard to the red and green

which are complementaries, however, this cannot be said. The red is a rather purplish red, and the green is a rather bluish green. In fact, the colors that seem to be psychologically pure red and pure green are not complementaries; when mixed they give pure yellow.

To account for the facts just stated, Ladd-Franklin suggested that in the course of evolution retinal receptors at first appeared which distinguished only between light and dark; that the "light" ("white") receptor became further specialized in such a way as to produce two different kinds of chemical change giving rise to experiences of yellowness and blueness; that, further, the structure of the "yellow" receptor became specialized once again so as to produce two substances sensitive respectively to red and green The Ladd-Franklin theory explains most of the phenomena which the Hering theory explains; and it has the advantage that pure reds and greens when mixed actually yield yellow, whereas Hering had to choose a purplish red and a bluish green in order to get gray

The Hering and Ladd-Franklin theories state that the reason for the appearance of the contrast color is the chemical relation between the substances which are responsible for any two such colors. The "yellow" kind of change in the retina, as one stares at the yellow paper, causes an antagonistic or balancing chemical reaction to occur in the neighboring region. The neighboring region then gives rise to the experience of blue. We have already seen that complementary colors are conceived as colors which neutralize each other because chemical balance is set up in the retina. *Both of these theories therefore put most of the "work" of color vision upon the retina.*

Serious difficulties are encountered by the Hering and Ladd-Franklin theories, as a result of evidence offered by Hecht, using the following method: A box is made with apertures for the eyes at one end and glass windows at the other end. Each eye looks through one window as it is fixated upon a distant light. If the windows are respectively red and green, the patches of color thrown upon the retina must be red and green. But, upon looking into the box, one sees *yellow* light. Similarly, if the windows

happen to be blue and yellow, one sees white (or gray) rather than either of the stimulus colors. Thus the color mixture is performed by the *brain*. Knowing the manner in which the fibers find their individual way through the optic nerve to the brain and how well insulated they are, we have a right to deny that these color messages get mixed up before they reach the visual center in the brain. Since experience of yellow would arise from looking through the left pane alone, when the left pane is yellow and the right is blue, we have a right to assume that these "yellow" messages get to the brain. Similarly, we have a right to assume that the "blue" messages arrive Something happens, however, in the brain, something the nature of which is probably both chemical and electrical; and what we actually experience is neither blue nor yellow, but white or gray. The experiment is offered not to close the very complicated problem of the physical basis for color vision, but as evidence that the brain must play a very important part not only in the *comparison* of, or preference for, colors, but even in just the *seeing* of them. As matters stand, the evidence seems definitely to favor the Young-Helmholtz theory

EYE MOVEMENTS

The eye is equipped with internal muscles which enable the lens to focus and the iris to adjust to variations in brightness, and also with external muscles which pull it about in various directions.

In following a moving object the eye sweeps along; but in reading or glancing at stationary objects it moves only in jumps, and permits definite vision only when stationary.— We often speak of the *fixation* of the eyes, and we tend to think of it in terms of prolonged riveting of the gaze upon a single point. Such fixation is, however, exceedingly rare, since the eye is among the most jumpy mechanisms known. Photography shows the eye to be constantly wavering and sweeping about. It has two quite distinct forms of motion. It has a "pursuit movement" consisting of a rather slow steady sweep, and a jump movement in which the acceleration and the slowing down are so rapid that most observers see only the jump as a whole. We speak ordinarily

of sweeping the eye over a scene, but actually we do no such thing. Watching stationary objects, whether these be room interiors or vast landscapes, we glance about from one spot to another. We have no voluntary control over the detailed movements of the eye in such cases; the eyes have learned to work jumpwise, and they know no other way. The sweep type of movement, or pursuit movement, occurs only when a moving object is being followed. Watch a friend while he is observing the passing of a distant train and then ask him to carry out the same sweeping movement while watching stationary objects, and the sharp difference between the two kinds of movements will appear.

The jumpy kind of movement has been intensively studied because it has wide psychological significance and a great range of practical applications. The psychology of reading has necessarily involved a careful study of the details of eye movements The photographic studies of the eyes in reading show that the jumps usually take in an inch or two, most readers making several pauses in reading a line of newspaper print. The eye swings back to the beginning of the next line, sometimes in a hesitating sort of way. It spends more time on the first half of a line than on the second half, a fact in harmony with the discovery that proofreaders' mistakes are more common in the latter half of the line

More intensive studies have undertaken to find out what it is that makes an efficient reader as far as these physical details are concerned, with the result that the more efficient readers are found to take in more at each pause and to make more jumps per minute. The number of backward or retracing movements of the eyes in a line is relatively small, but increases greatly as the difficulty of the reading matter increases. All this presupposes that the eye is built to see clearly at the instant at which it is fixated at a given point; the fovea, or point of clear vision, is in fact very small, and objects must impress themselves upon it to be clearly seen. Not only is this true, but more intensive study shows that the eye sees only during fixation. That is, while carrying out its ordinary jump movement, the eye fixates and reports clearly what is in the immediate neighborhood of the fixation point; then, while it is in the process of moving to the next point,

vision partly determines, of course, the length of the sweep which will be practical for the reader; but familiarity with the material may make it possible to take in several words at one glance. Relative clearness rather than absolute clearness is all that is involved here; the reader takes in words or groups of words. It is not necessary that every square millimeter of the observed surface should stand out as clearly in the moment of observation as it would if the eyeball were moved about within this surface to get the clearest possible view of every point

A good width for a column would seem to be about 3½ or 4 inches, indicating that the newspaper column is not materially smaller than it should be for effective reading. The fixation pause of the eyes in reading material of this sort averages about a quarter of a second, but it varies greatly. A group of sixteen students reading lines sixty-seven millimeters long made on the average 5.9 pauses per line. This involved, of course, many instances of taking in two or more words at one glance.

In speaking of eye movements we have implied a partnership between the two eyes, but one eye is practically always dominant over the other. We "sight," or "aim," with one eye and the dominant eye carries the other along. The children shown in Fig. 45 are "aiming" at the experimenter as he takes the photographs In the two photographs every child but one shows consistent dominance, aiming twice with the same eye.

SUMMARY

Light waves are refracted by the cornea and lens and are focused on the retina. Form vision is best at the fovea. Faint colorless impressions are received by the rods, which function best when the eyes are completely dark-adapted Color impressions are received by the cones, which function when the eye is light-adapted. The amplitude of light waves determines brilliance; the wave length determines hue or color; the purity of the wave length determines saturation. In respect to contrast and after-images, red and green, blue and yellow, black and white constitute pairs. The loss of red and green is the commonest form

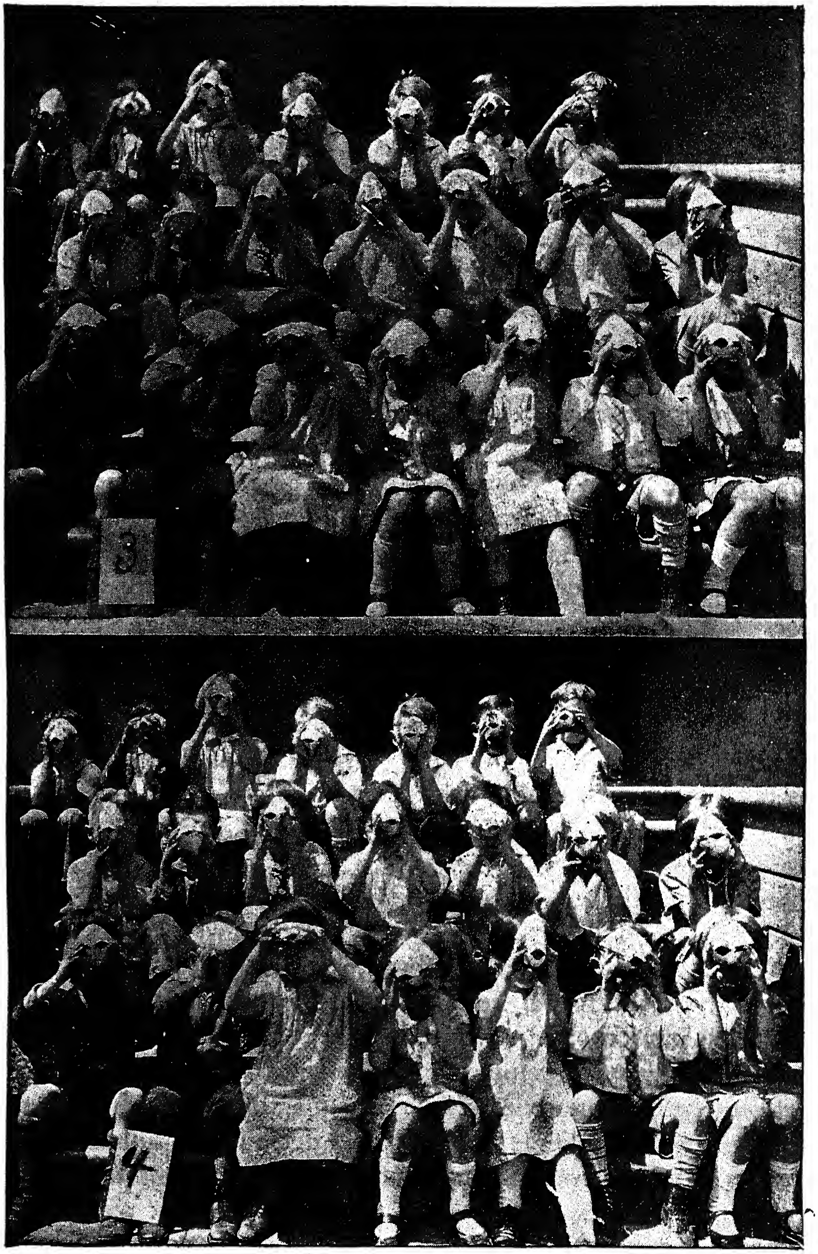


FIG. 45.

of color blindness Though the theory of color is controversial. most of the facts fit the view that (a) there are in the retina receptors for red, green and blue; and (b) color mixture, color contrast, etc, depend largely upon what happens in the brain after the impulses from these three kinds of receptors get to the visual center in the brain (Young-Helmholtz theory).

REFERENCES

Herrick, C. J, *Introduction to Neurology* (5th ed.), 1931, Chapter XIV
Helmholtz, H L. F von, *Physiological Optics* (4th ed), 1925.
Ladd-Franklin, C., *Colour and Colour-Theories*, 1929.
Ladd, G. T, and Woodworth, R. S., *Elements of Physiological Psychology*, 1911, Part II, Chapters II and V.
Murchison, C. (Ed), *Handbook of General Experimental Psychology*, 1934, chapters by C. H. Graham, S Hecht, and L T. Troland.
Parsons, J H, *An Introduction to the Study of Colour Vision*, 1915
Titchener, E B, *Experimental Psychology* (4 vols), 1901-05
Vernon, M D, *The Experimental Study of Reading*, 1929
Warren, H C, and Carmichael, L, *Elements of Human Psychology* (rev ed), 1930, Chapter V.

PROBLEMS

1 Recent experimental work suggests that rods and cones and their nerve fibers act according to the all-or-none law How can this be reconciled with the apparent smooth gradation from low to high brightness?

2. The next time you have an opportunity to look at a sunset, watch it for five minutes as you ordinarily do. Then bend over at an angle of 90 degrees so that you can look at it "sidewise." What happens to the sunset? Look at any vividly colored scene as you usually do, then look at the same scene through colored glasses of a hue different from that which is dominant in the scene After looking at the scene through the colored glasses, look at it again without them. Compare your impression of it this last time with your experience of it the first time What do these experiences suggest regarding the effect of habit and adaptation?

3 How can the fact of color blindness be used to test the question: Is the blue which one person sees the same as the blue which other people see? Could one person's blue conceivably be yellow to another if neither individual ever discovered the difference?

CHAPTER X

THE DEVELOPMENT OF PERCEPTION

Perception is the interpretation of a sensory stimulus.—In the last three chapters we have studied the ways in which stimuli act on the sense organs, and the simpler types of sensation which result from this stimulation. Even in the fields of hearing and sight, which are considerably more complicated than the other senses, we have considered only relatively simple elementary things, like the sensing of tone and color, and not the actual complete process of seeing and hearing The distinction is made in psychology between sensing a thing and perceiving it The distinction lies in the fact that, except possibly in the newborn organism, things are not sensed without being given some interpretation in the light of past experience. We learn to see things a certain way. We perceive the faces of our friends to be distinctive of different individuals, while the faces of Chinese seem to us very similar To the Chinese it is incomprehensible that we should find all Chinese faces so much alike To the person unskilled in music, nearly all modern music sounds much alike; to the person who knows what modern music is all about, it is incredible that anyone should confuse the different kinds of modern music with one another. Even a simple sound, a single syllable of spoken language, is a different thing to different people It is interpreted as an expression of scorn or joy, depending upon the language used by the listener. The same intonation which for us means emphasis is given to many sounds in certain other languages merely as a part of the normal flow of speech, and no emphasis is intended. A word, moreover, has a specific *meaning*. When we hear a word, we hear not simply the sound, but a pattern in which sound has a certain context. A white object in the dusk may be to us a mere floating white surface; it may be seen as a

newspaper; it may be seen as an escaping animal, or even in a certain mood as a ghost It is quite futile to treat all impressions as if the sense organs determined their characteristics. Most of what we see is seen and interpreted at the same time. Interpretation is literally part of the act of seeing. The same is true of all the other senses. We look about us and interpret; we listen and interpret, our fingers move over a surface and interpret, etc.

For example, we usually see colors in terms of what we believe them to be.—We have already considered the hue, brightness and saturation which come from colored surfaces. Colors are, however, perceived as parts of a context, a pattern of varying colored surfaces. Any purely physical view of the effects of light waves upon the retina neglects the curious fact of "color constancy," the fact that the experience of a given color may arise from entirely different wave lengths or combinations of wave lengths. If, for example, a given object which is known to be red is carried about in a variously lighted room, the object ordinarily seems red all the time. As a rule we do not even notice its rapid change of color. It is, however, easy to show that the actual physical aspects of the light wave, its amplitude, wave length and purity, result at one time in what we should call a muddy brown if the patch of color were shown under standard laboratory conditions of illumination, etc., and at another time in what we should call a sickly yellow if it were presented under the same standard conditions. The fact that we *know* the object to be red makes it seem red. In other words, we interpret it as red. It is only in the early evening that we usually notice the changes in color which objects show as the illumination fails. As a matter of fact, objects change in hue, brightness, and saturation, all day long. The same general principle holds good in the simple comparison of light and dark grays when no hue is used In a recent study using disks illuminated with light of various brightnesses, students were found to regard the same gray surface as very *bright* or very *dark* while various changes were made in the room which altered backgrounds *without changing the actual light* coming to the eye from the disks. In such experiments changes

even in the remote background of the stimulus are important, for example, changes in the amount of light striking the side of the retina from a source several feet from either of the surfaces which are being compared, and completely screened off from them. We simply cannot help interpreting, in terms of surroundings, what comes to our senses. The writer can testify that the illusion remains in full force even when its dependence on surroundings is fully understood.

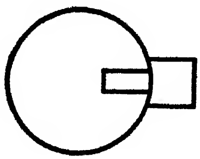
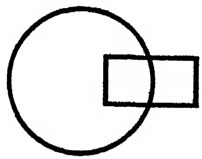
Interpretation usually depends on grouping or organization of sense impressions.—In the case of color constancy or brightness constancy, we have a single sensory stimulus interpreted by virtue of its surroundings and the attitude of the observer. The object to which the person is attending in these experiments is *one simple stimulus* like a gray surface; there is no problem of *grouping* or organizing what is seen Ordinarily, however, objects to which we attend are more complex Most objects that we see have parts which are of different color and shape; yet we organize these into compact *wholes.* Note how a table, a book, a telephone, a picture are grasped instantly as wholes. How do we know where the edge of the picture is? If a series of books is in front of us, how do we know where one stops and the next begins? There are boundaries, of course, and these help us to group the sense impressions into different wholes, each one separate from the next Sometimes, however, we arbitrarily *create* boundaries We may look off at a range of hills, noting, as we do so, that the "state line" follows a certain valley. We observe that one hill belongs to one state and another to a second state. As we think of the state line, we divide all the hills into two groups. When words are spoken, they seem to a foreigner to have no beginnings and endings. There is simply a "flow" of speech. A common complaint of a person learning a foreign language is that the natives of the other country "run their words together." Not only do we group things in accordance with natural boundaries, actual spatial distance between them, and so on, we group them in terms of our own habits We learn to impose upon them boundaries and barriers which make it

possible to grasp the world about us as a series of definite and convenient objects. Instead of the vast jumble of confusion which the world probably is to the newborn infant, most of it is to us an orderly pattern of objects. *By far the most important single fact about perception is that we interpret by virtue of the way in which we group and organize separate sense impressions.* We know how to combine certain sounds which are uttered as we listen to the man who is talking. We learn how to mark off and perceive as unified wholes the objects which we encounter as we move about from one place to another. This process of unifying or organizing sense impressions so that they are grasped as wholes is the chief clue to an understanding of the way in which perception or interpretation of sensory stimuli differs from mere sensation.

Retinal impressions are grasped as wholes.—The retina is spread out right and left, up and down; thus the eye is equipped to report the different positions of objects. It used to be believed that each point in the retina had a corresponding point in the visual area of the brain. The retina was therefore said to be "spread out in miniature" in the brain This would be a solution of the problem of how we locate objects in relation to one another, as right and left, up and down (it would not explain the perception of the third dimension; we are speaking only of the two-dimensional surface as a photograph or painting would record it). According to this theory, the fovea is a sort of point of reference, and everything seen is projected on the retina in a certain relation to the fovea, above or below it, to the right or left of it. This is partly true.

But the facts are really more complicated than this. The act of seeing is an act of organizing sense impressions, and this organization is the chief clue to an understanding of how we really see. We make use of the relation which each point bears to the fovea, but we do a great deal more An example from war-time experience throws much light on this. In the study of cases of injury to the visual brain centers, some cases of blindness in a *part* of the visual field were found. The men were not totally blind;

they saw in blotches and were blind in other blotches. In such cases of partial blindness the eyes would often see things as wholes although they had only partially registered themselves on the visual apparatus. A circle was seen as a circle even though half of it fell in the blind field. The subject filled out the picture. But it was not sufficient to say that the subject's past associations served to supply the missing parts. An actual functional shift in the fovea occurred. If, as a result of brain injury, the fovea had become non-functional because the brain could not receive impressions from it, another part of the retina became the point of clearest vision, the functional center or dominant point. This dominant point was called a pseudo-fovea. The retina seems physiologically incapable of yielding clear vision except where the special structure of the fovea permits; yet as a matter of fact, where experience is as highly organized as it is in vision, the entire field may be completely recast as a result of change in one part. One patient, for example, suffered from a local "micropsia"; i.e., there was a region in which everything seemed small though the rest of the field of vision was normal. When an object was presented which fell partly on the microptic field and partly on the normal field, he often saw the whole thing as of normal size.

He saw not  but 

Here the brain obviously responds in an organized way. It makes a unity of what is seen. Even a two-dimensional world is more than a simple surface photographed on the retina.

There are several distinct cues by means of which the *distance* of objects may be judged.—We not only interpret two-dimensional impressions. Ordinarily we see and interpret in three dimensions. How can the vertical and horizontal spread of the retina give us the capacity to perceive the third dimension—

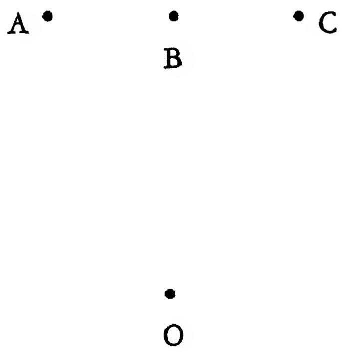
to judge how far or how near things are? There are many cues which help in doing this: (1) A beam of light striking the cornea is refracted several times by the various parts of the eye and by means of the function of the lens is thrown on the retina in such a way as to focus. The convergence of beams of light to give sharp focus depends upon the length of the eyeball and the action of the lens; if the eyeball is too short or too long, the lens is unable to focus normally. The lens, in other words, can work only between definite lower and upper limits. It can adjust for vision at a distance of a few inches or for objects far away. Contraction of the lens is probably effected in part by muscles which have their own appropriate incoming pathways to the brain, so that the state of contraction of the lens at any given time is reported to the brain. This is one of the many cues by which distance is judged We need not, of course, be *conscious* of the muscular contractions; the estimation of distance, though guided by these impulses from the muscles, is "automatic," just as our maintenance of bodily posture is ordinarily "automatic"

We make use of several other cues besides those given by the lens mechanism (2) The superposition of one object upon another, (3) foreshortening due to distance, (4) presence of haze and of shadow—indeed, a great variety of factors which ordinarily distinguish objects which are at various distances from us—are used either consciously or unconsciously We have learned, for example, that distant objects ordinarily appear hazier than near ones Yet we do not consciously reflect on the haziness of an object in order to judge it farther away than a similar object which stands out more clearly.

(5) In addition to these four cues just mentioned, all of which help in the perception of distance even when one eye is closed, there is a second group of cues which are given only when both eyes are in use. One of the most important is the fact that slightly different aspects of the same object are seen by the two eyes.

Persons who have had a defect or serious disorder of one eye

at an early age may sometimes be able to deal with the third dimension as well as those who have the use of both eyes. They may even carry out complicated adjustments such as are involved in playing baseball. In general, however, those who lose the use of one eye *after* growing up never achieve anything like the degree of proficiency in judging distance which normal vision gives. The superiority of binocular over monocular judgment of distance is extraordinary—much greater than one would guess offhand. Two pegs, A and C, are fixed at the same distance from an observer O,



and between A and C a peg B is attached to a sliding plate which makes the peg movable back and forth, the observer now undertakes to find out how nearly he can succeed in sliding peg B to a point on the line AC. While using both eyes, the error at a distance of two meters is rarely as great as 1.5 millimeters, whereas with one eye closed the error is several hundred times as great.

Holding a finger at arm's length and looking at it first with the right eye, then with the left, then with both, makes one aware of the slight differences between what is reported by the two eyes. The farther the object, the less the difference between the two reports, until, as we reach a hundred feet or so, this type of cue drops out for most objects. The importance of this "stereoscopic" effect is apparent in the tremendous advantage of close-range over long-range judgment of distances. The dependence of three-dimensional effects upon this factor is brought out by the stereoscope; cf. Fig. 46.

A laboratory experiment requires the subject to compare three figures. The first gives two identical copies of the same photograph; the second gives a stereoscopic effect, due to the fact that the two parts of the second photograph were taken from points about three inches apart by means of a stereoscopic camera. This gives a good "solid" three-dimensional effect. The third is seen "wrong way to" because of the reversal of the true positions; the picture is seen wrong because the right eye is seeing what

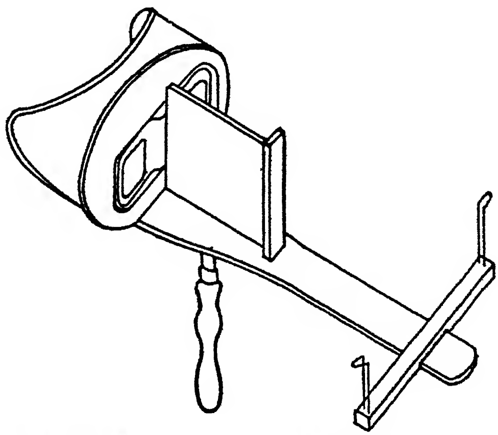


FIG. 46—The Brewster refracting stereoscope. Slightly different pictures are presented separately to the two eyes. When properly adjusted, the pictures fuse and give a tri-dimensional effect.

was taken by the left camera, and conversely. (This remark about reversal holds good for most objects, but not all objects can be made to reverse.) On the basis of such findings, it is known that the stereoscopic effect is the chief single cue used in short-range observation to give the effect of solidity, or the awareness of the third dimension

(6) There are, however, other binocular cues. Probably the external muscles of the eye, which are held taut at different angles when objects at various distances are observed, contribute their own quota of messages to the brain, which we have learned to interpret in terms of distance. If, moreover, any near object

is fixated with both eyes, the background will be seen double though we do not ordinarily notice it; and if a distant object is fixated, the foreground will be seen double. An easy way to try this out is to hold the two index fingers horizontally about six inches in front of the nose and about an inch apart pointing toward each other, and to look steadily at the wall beyond. Each finger is seen double, but two of the four fingers are transparent except in the small area where the images overlap.

The fact that different brain patterns are excited whenever we use both eyes in observing leads easily to a definition of perception in terms of *integration*. Separate brain activities if aroused independently might give rise to separate sensations; but when they are aroused together the pattern of activity in the brain gives synthesis or unification. When integration of all the sense impressions is difficult or impossible as a result of the completely different character of the thing seen by the two eyes, we may see one thing or the other, but ordinarily not both. This is illustrated by a standard experiment on *retinal rivalry*. In a stereoscope one eye looks at a red cardboard and the other at a green one. Under these conditions the right and left fields take turns in controlling what is seen, or, strictly speaking, the two things are seen in turn by the organism. One sees red for a number of seconds, then suddenly the red is completely gone and there is green in its place. The effects alternate instead of fusing. One activity is at a given time dominant over the other. It is not possible for us under these conditions to integrate or unify the two conflicting impressions Since perception means unification, this is just another way of saying that we cannot perceive two colors as being directly in front of us at the same time. It is contrary to all our habits to see a complete red surface and a complete green surface in the same place at the same time. We noted above that under special laboratory conditions it is possible to make the two brain responses, the red response and the green response, yield a different response, namely, a yellow. This, however, is under those unusual conditions when there are no conflicting habits which step in and determine how we shall see The rivalry experiment shows

the influence of habit in various other ways. We have already noticed the importance of habits of depending upon one eye somewhat more than on the other If one color predominates over the other one about three-quarters of the time in the rivalry experiment, it will be due in most cases to the fact that that color strikes the dominant eye. To test this factor it is necessary to turn the card upside down and to run a series of tests under the two conditions. If there are standard rivalry cards in your laboratory, take your record for two minutes, counting the number of seconds within this period in which the figure on the right is seen, and the number of seconds in which the left figure is seen; then turn the card upside down and repeat.

The rivalry experiment is of special value in showing the importance of integration. At first glance it might seem that our failure to unite two colors is an exception to the principle of integration As a matter of fact, however, it is a clear example of the principle, since the reason why we do not see the two colors at once is simply the fact that we cannot organize them that way because of our basic habits of observation.

In reality, we consistently ignore in everyday life a great deal that is contrary to our wishes or expectations. What is before our eyes may not be in harmony with the pattern for which we are looking. Malinowski tells how the people of the Trobriand Islands, who believed that a person inherits entirely from the mother and not at all from the father, were shocked at him when he pointed out the great resemblance of two kinsmen who "ought not" to resemble each other The idea that these two men looked alike seemed absurd to them The Trobriand Islanders were incapable of seeing the resemblance because their whole view of life denied it. In the same way we cannot see any sense in caricatures of ourselves although the likeness may be fully appreciated by our acquaintances.

We also experience space through the skin senses. In addition to the various kinds of sensations from the skin—warmth, cold, pain, and touch—there is something which makes it possible to

tell *where* on the body we are being stimulated. If the eyes are closed and other non-cutaneous cues are eliminated, one may apply the same gentle stimuli at different points on the body and get prompt and accurate reports as to the place of stimulation. How is this fact to be reconciled with our theory of the identity of the warmth sensations wherever they appear? The best interpretation is that every such cutaneous stimulation tends to produce slight movements of adjustment or orientation, which were originally derived from reflex responses but have been developed through training. Every light touch on the left arm, for example, involves not only characteristic slight reflex retraction of that arm, but slight reaching movements of the right arm, such as are involved when we reach over to touch or scratch an irritating point on the other arm. In this way, every point would have not only its qualitative characteristics, as touch, pain, etc., but a certain definite relation to the world of space. Each spot, when stimulated, turns, or orients, us in one direction. In other words, our notion of three-dimensional space depends ultimately upon these tendencies toward movement, or *orientation tendencies*, inherent in the way in which our bodies adjust to stimulation at various points At least there is no doubt whatever that the topography of our bodies and the spatial relation of points on the skin have to be learned; this knowledge is not innate

In exactly the same way, every spot on the retina may be regarded as having, in addition to its capacity to respond to qualities of hue, saturation, and brightness, a "local sign" by which we are enabled to place each seen object at a certain point in the spatial order. While fixating one point, we judge directly, and without any reasoning processes, that another point is just above and a little to the right, or directly beneath the object observed. Since each spot on the retina conveys qualities which are more or less the same as those which may be conveyed by other spots, the retina alone would not be able to tell us the relative location of objects. The separate spots on the retina would pour in upon us a jumble of qualities. How do we make a spatial pattern or whole out of these non-spatial elements? Again, the

answer is probably in terms of our tendencies to movement. First, the reflex tendency of the eye to move toward the bright object appears in newborn infants long before the eye can focus and before the eyes work in good coordination together. Second, there are learned responses built up through our tendency to reach or feel for objects because they are actually found in such and such relations to the world of our muscular adjustments.

For example, if lenses are worn which reverse the field of vision, right and left, the world is at first actually seen as if in a mirror. If we reach for an object immediately after putting on the lenses, and find that the hand has gone too far to the left, we reach to the right, or what we think is the right, with the result that we make an even worse error But within a few days the process of dealing with the world in a direct way with our muscles brings about a new set of habits After practice, we not only cease to make faulty moves—that is, we build up a system of movements which are well articulated with the visual stimuli acting on us—but we actually *see* the world differently That is, what we call left in our visual world is what we call left in our world of muscular response After taking off the lenses, we again make our adjustments the wrong way around, but we quickly get back to the normal way of seeing Such experiments strongly suggest that to see the world as a three-dimensional world and to experience it through the skin as a three-dimensional world both depend on the fact that we first of all *act* in it as a three-dimensional world; our muscular adjustments impose a spatial character upon what we perceive with our eyes and our skin

Some authors suggest that a person lacking both eyes and cutaneous sensibility would lack all space consciousness. But in view of the fact that every one of the senses leads to our making definite use of the world of physical space, this view is hard to maintain We learn that things are up or down, right or left, far or near, in terms of what we do, or would have to do, to manipulate these things Just as we learn to mark off the objects of the external world and to find names for them chiefly in terms

of the ways in which we use them, so we learn to build up a world of spatial extension by actually using such a world.

Attempts were once made to show that the capacity to perceive space is innate Thorndike reported that young chicks placed on boxes a few inches high would jump right down; on boxes a few inches higher, they would first hesitate but then finally jump; and on boxes thirty-nine inches high they would not jump. This was supposed to prove that animals have an innate tendency to estimate distance correctly. Thorndike's results are correct for chicks which have had the experience of jumping and hurting themselves, but not for chicks which have had no such experience. In a recent study at the Columbia laboratory, chicks reared in cages and having no experience of falling have had to be restrained when their cages are opened; those which were not restrained at first jumped eight feet from their cages to the concrete floor and were killed.

Large quantities of anecdotal reports regarding the innate capacity for space perception have been similarly disposed of. Little children may possibly have some innate capacity of this sort, but it is unlikely, for their struggle to get control of the third dimension takes years

Though a spatial order is built up with the aid of the eye muscles and of many muscles of posture and locomotion, these different muscles do not agree perfectly by any means, as may be shown by making a subject reproduce with his arm a distance marked off by two pointers on the thumb and forefinger, or making him reproduce by a sweep of the eye a distance measured off by the arm as it is swung freely. The eye, for example, greatly underestimates distances marked off on the hand and arm. Moreover, simple geometrical forms which are perceived *by touch* do not automatically take on meanings of form corresponding to *visual* geometrical forms; but these tactual impressions make the subject recall the visual appearance, and the two forms of experience are tied together as a result of association. We are not born perceiving one systematized spatial order; we slowly learn to fit

together the miscellaneous sense impressions, so that one form of sensory experience can be translated more or less into the terms of another.

There are still other important aspects of space experience. Experiments with subjects who, while blindfolded, are revolved in a practically frictionless revolving chair make it clear that changes in speed of movement give a definite awareness of space, aside from any experience coming through the eye or skin. Space perception in this case results from mechanisms in the inner ear near the cochlea, consisting of the vestibule and semicircular canals shown in Fig. 34a on page 134. The figure shows that each of the three semicircular canals is in a plane perpendicular to the others. There is a fluid in these canals and in the vestibule, and movement of this fluid is thought to be important to the space sense. But this whole mechanism is so deeply embedded in bone and there are so many experimental difficulties that the problem can scarcely be said to have been adequately pursued. In fact, most of the problems regarding perception of space by these mechanisms have scarcely been stated in experimental form. Disease of these structures does definitely cause disorder in response to space. Various non-spatial effects of stimulating this mechanism are well known; for example, seasickness or dizziness, which leads to the discharge of energy down the nerves from the semicircular canals to the digestive apparatus. These sensations from the digestive organs are similar to other sensations in which the semicircular canals and vestibule are not involved, so that they throw little light on the question of what the normal elements of experience may be which arise directly from excitation of the vestibule and canals. Probably there are no true sensations from these organs; but they play an exceedingly important part in maintaining posture and bodily balance and thus contribute greatly to the effective use of our muscles. Since perception of space depends partly upon our muscular responses to the world of space, the vestibule and semicircular canals are among the most important organs which play a part in space perception.

STAGES IN PERCEPTUAL GROWTH

Objects are seen by little children in terms of differentiation of background from foreground. The foreground objects—those which, in an adult, we should call the objects *attended to*—differentiate themselves month by month as a result of experience and perhaps also as a result of the development of the nervous system Whether the different patches of color within the field of vision are responded to as *separate sensations* and later *put together by association* constitutes a difficult problem. Classical psychology believed that the first experience of sight involved the seeing of the separate patches and that later on, by virtue of associations formed, the child would put the parts of the pattern together—in other words, "perceive" it Again, by virtue of association, the child would be able to perceive the whole even when only a part of it was presented. The assumption was that sensations are connected up by experience, so that most of our adult life involves dealing with things like houses, trees, songs, dinners, or insults—each of these being a complicated pattern of sensory stimuli A man born blind and receiving his sight as a result of a surgical operation at twenty years of age, would, for a few days after the operation, receive pure sensations—the raw material from which a visual world is to be built up by association. Operations of this sort have in several cases been successfully performed The results do, indeed, indicate that objects seen for the first time are rather meaningless, just as the sounds of an unfamiliar foreign language are meaningless because they are not connected with our previous experience of it On the other hand, these operative cases do not yield visual experience of anything like the primitive sensory character which might be expected Of course, the patient does not know what he is seeing, but the very first objects seen are wholes, not just mosaics made up of little bits And they have some vague spatial character As we should expect from the biological fact of organization and unified behavior of the body as a whole (page 47), the earliest

acts of perception seem to be total responses of the organism. The operative cases learn gradually to break up these wholes so as to differentiate within the sphere of visual experience. In the course of time that which was at first a confused whole can be differentiated into patches of color which have various sizes, shapes, hues, brightnesses, etc. This is not so different from what we should expect if we recall the experience of trying to "make out" something at a distance in the twilight, as noted at the beginning of the chapter. The object may at first be a confused whole. Gradually, as we study it, we can break it up and begin to see the parts so that at last we may suddenly integrate the whole and interpret it.

The development of perception involves three steps: (1) an undifferentiated whole; (2) separate sensations; (3) an integrated pattern.—The process of passing through vague undifferentiated *wholes* to specific recognition of *parts*, and then on through to a *third* stage in which the parts are *integrated* or thrown together into a new and meaningful whole, may be shown in the experiment which made use of the materials appearing in Fig. 47a The objects when first glanced at were nothing in particular. They had no character, no meaning When they were closely scrutinized, parts began to appear distinctly; then other parts suddenly became clear. There will be individual differences between people in the exact nature of the process of perceptual development in relation to each figure. In some cases the ink blot takes on instantaneous meaning as a whole without any clear passing through the stages which have just been defined. The second picture in Fig. 47a was first seen by the writer as completely meaningless. Then his attention fell on the upper left-hand smudge which he saw clearly as a lion cub's head. A moment more led to the perceiving of the lower right-hand part of the picture as the hind legs; and despite the fact that the picture is full of irrelevant details when seen as a lion cub, it passed rapidly to the complete animal, the extra parts being thought of merely as bumps or a blanket thrown over him. No 8 in Fig. 47a was instantly seen as a man with an old-fashioned military cap. Prob-

ably all the figures in 47b will seem to the reader to take on organization almost at the instant at which they are first examined.

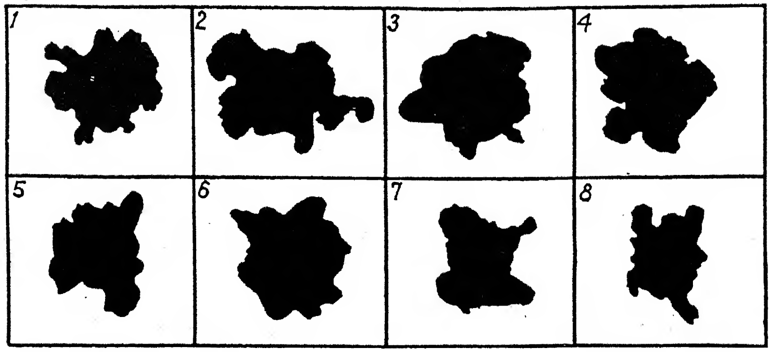


FIG. 47a.

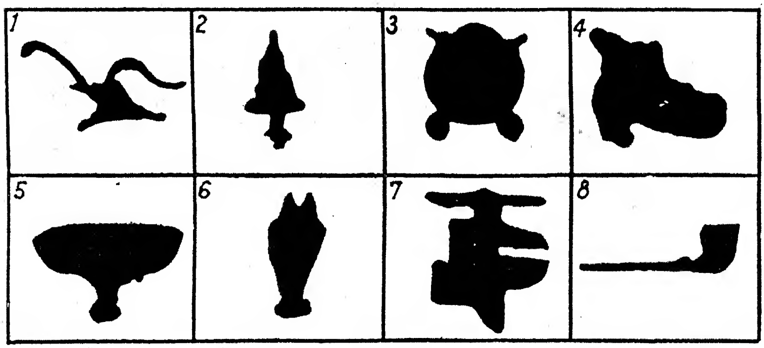


FIG. 47b.

FIG. 47.—The development of perception. These forms were used in a study of the development of perception in normal individuals. The forms numbered 1-8 in 47a are nonsense forms; those in 47b represent some familiar objects. Try to see each of the forms as some object. From G. L. Freeman, *J. Exper. Psychol.*, 1929, vol. 12, p. 344. By courtesy of the editor and the author.

It seems likely, in general, that the development of perception in early childhood manifests *analysis*; that is, the little child progresses not by *fitting together* bits of sensory experience, but by finding ways in which he can analyze or *split up* what is at first unique. When a six-year-old boy drew a cylinder, he drew

a circle (for the top), an *ellipse* (for the curved surface), and another *circle* (for the bottom). His trouble lay in the fact that even at this age the process of analysis is imperfect. It would be ridiculous to argue that the six-year-old boy *sees* the cylinder as

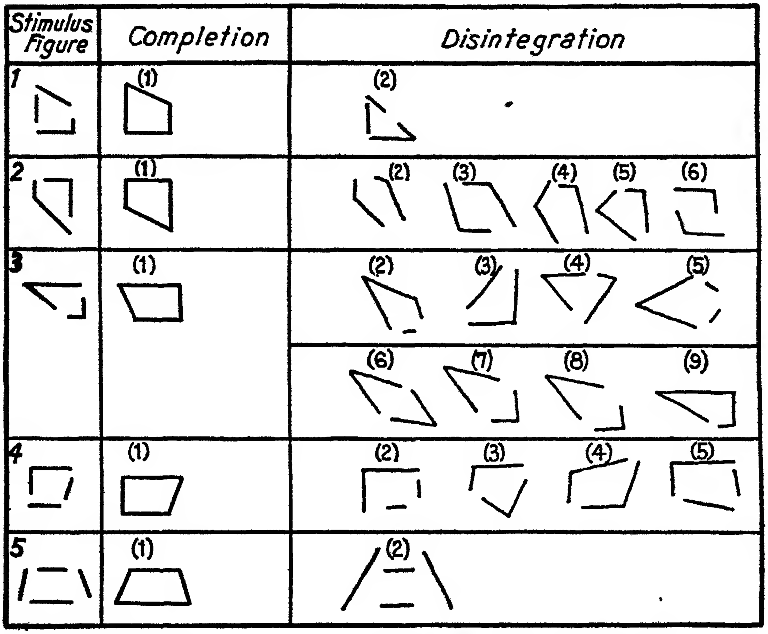


FIG. 48—Tendencies in adult visual experience. These figures from an experiment with adults illustrate two tendencies in perception (1) completion, the tendency to fill in the gaps in contours, and (2) disorganization, the tendency to let the figure fall into separate units The stimulus figures were shown separately for about 1½ seconds each After a series of fourteen such stimuli had been presented, the subjects drew as many of the figures as they could remember, in any order Some of the responses to five of the stimuli are here reproduced, classified as to the tendency they represent completion or disintegration From J J. Gibson, *J Exper Psychol*, 1929, vol 12, p. 28. By courtesy of the editor and the author.

two circles separated by an ellipse We know that children of this age can handle cylinders skillfully and can match them properly with others of similar size and color. But when it came to drawing one, the act of visual perception and the act of muscular execution stood in a relation which made it very hard

to transpose elements from one unit to the other Since the boy has no innate tendency to copy a cylinder, and no innate tendency to indicate the appropriate lines and surfaces, he must somehow find a way of breaking up the cylinder and making his hand go the right way in order to show the parts before him Evidently this kind of analysis, even with the use of language, has not yet come to him It comes slowly; the little child "draws what he knows, not what he sees" The little child sees its doll as a whole, but as it notices more and more closely and learns to pay attention to each part separately, it comes at last to have independent sensations For example, it sees that the doll's eyes are blue and its hair yellow.

Fig. 48 illustrates two aspects of what we have been discussing The first vertical column shows stimulus figures which were presented to the subjects. In some cases the subjects when asked to reproduce the figure reproduced it as shown in the second column They had already had enough experience with lines and geometrical forms to get the completed figure which the lines suggested. They took the broken lines which might appear as parts of a whole, and a unified act of perception made the whole figure what it would be if the lines had been complete. They were reacting at the *third* stage of perception The subjects whose work is shown at the right-hand side of the chart, however, did not get so far. They saw the separate parts as if they were working at the second stage of perception. They did not see the whole suggested by the lines. When it came to reproducing what they had seen, some of the parts dropped out. Those which remained are not sufficient to suggest the original whole so they are merely reproduced piecemeal In general, the whole, if completely grasped, will tend to be reproduced as a whole If only certain parts have been grasped, some of these will drop out before one reproduces what he has seen, and what is reproduced will therefore be less complete than what was presented.

Sensation may be derived from perception.—Such considerations as these make it unlikely that all perception is a mere product of sensation, a mere synthesis of separate sensory ele-

ments. Perception not only puts the parts together; it gives them a certain definite *relation* to one another. The perceptual whole is not a mere sum of parts. It has organization; it hangs together When the perception is once complete, it becomes very difficult to disentangle the separate sensory elements which played a part in arousing it. In fact, perception seems to alter the characteristics of the sensory elements so that they are no longer the same things that they would be if they existed isolated from one another. The various odor, taste, temperature and touch sensations which come from a beefsteak or a dish of ice cream are so completely lost in the total experience as we eat it that it is doubtful whether the separate sensory elements can be said to be there any longer Do the vanilla odor, for example, and the peculiar touch quality of the ice cream on the tongue, exist somewhere in the subject's experience as a true sensation? On the whole, probably not Under certain special conditions such as those possible to the trained laboratory observer, sensations may become capable of detachment from everything else and may be regarded as pure elements This is of importance in certain analytical studies. This fact, however, does not prove that these sensory elements had an independent existence, each by itself, all the time prior to the beginning of the laboratory investigation. We may learn to note what appears in consciousness after special training in introspection; this does not prove that what the introspective psychologist reports was there in the mind of anybody, even his own, *before* he started to analyze. On the contrary, the term sensation is properly applied only to the special products which arise from certain special processes of analysis In general, what the introspective psychologist does when he analyzes is to pass from the third stage back to the second stage in the development of perception, or to pass forward from the first stage to the second. To pass from the first stage to the second is probably the more common The introspective psychologist takes something which to most of us is rather a blur, rather hard to analyze and describe, such as the taste of beefsteak, and by careful work breaks it up and gets a clear consciousness of each sensation element. Probably

all of us in growing up and in learning how to handle each new type of experience do a good deal of this same kind of thing In the child's early experiences with food, or pain, or fear, it is legitimate to describe the child as having taste sensations and organic sensations from the body, but not as if these stood out sharply each in its own light as they do with the introspective psychologist, for these things are probably inseparable aspects of what is for the child a totality, a unique and unanalyzed whole. The child is not aware of each sensation as a separate thing Only long experience prompts it to split off these aspects from the total.

Sensation, then, is an aspect of perception, an aspect which remains merely an aspect until under special conditions one has learned to detach and therefore to observe the quality in and for itself, set off sharply from all the rest of the mental background. When these separate sensations have been clearly observed they can be clearly put together in a new synthesis, and that is what we do all the time as we read or listen to conversation. The typical development of perception, then, is this: (1) an unanalyzed total is experienced; (2) separate sensations appear; (3) new combinations of sensory elements make a new perceptual response possible The way of grouping, interpreting and perceiving may change from moment to moment as our interests and habits make new groupings and interpretations possible

We must next turn to a closer study of this third process, the organizing and unifying of the separate sensations After analysis has been carried out, there may be a true synthesis or fresh organization of the elements. In discussing the gradual appearance of action patterns in infancy in connection with the concept of maturation, we saw that the development of the individual proceeds from the general to the specific At a later stage, what has once become specific may become integrated with other specific elements, and a true integration may be achieved. The reflex acts of the infant appear as late expressions of the nervous system's capacity for organized control (cf page 40); yet reflexes may be put together into new patterns in every skilled act In exactly

the same way, the gradual differentiation of specific sensory qualities from perceptual totals is followed by a new patterning or *integration.* After one has learned to see the separate aspects of what was at first an unanalyzed whole, he may slowly achieve a new way of combining the sensory fragments.

A useful distinction is made by Woodworth between those acts of perception which result in *patterns* and those which result in *blends.* The taste of lemonade is a blend; it is a unique experience. We are not ordinarily aware of the separate sensations of sour, sweet, touch and cold. A velvet or a silk surface is also perceived as a blend, a unique experience; we can recognize the quality which we call the feeling of velvet or silk without being able to tell the exact difference. On the other hand, a group of stars which make up the Dipper or the Crown can still be observed as individual stars if we wish to do so These are not blends, but patterns, for although they are organized wholes we can still *pick out the parts* easily whenever we wish Blends and patterns, then, are two ways in which perceptual experiences may be classified. This distinction of Woodworth's corresponds to what we have said about the difference between perception at the first level and at the third level. Under ordinary conditions the taste of lemonade is a blend; it is a whole or unique experience which has not yet been broken up at all. It is not a true synthesis, for it never has been analyzed. The perception of the constellation of stars, however, is a third-level perception. We do not observe the seven stars of the Dipper as a mere number; they make a pattern. Stars are objects which we have learned to experience separately; we may consider them as a group and see the Dipper as an organized whole It is unfortunate that the term perception is used for processes at both the first and the third levels. The third level seems by far the most important for emphasis here.

Language plays a very important part in perceptual analysis.—That analysis is a slow process, we know from studies of children's drawing, modeling, building with blocks—in fact, nearly all their creative activities in which perception and the products of perception can be directly studied. After breaking up

the world into parts which can be separately perceived and handled, the child learns to combine He does so partly in terms of observation of things which go together—that is, by simple association—and partly through the aid of words. The very patterns of the physical world are, in large part, marked off for us by speech For example, snow is for us just one thing; but the Eskimo, to whom snow is perhaps his first reality, has no word for snow as snow. He has four words, one for falling snow, one for snow lying on the ground, a third for caked snow or snow in blocks, and a fourth for snow which is drifting. On the other hand, the most diverse objects which are presented to him by an explorer may all be labeled by him with one common term It is not enough to say that he really sees differences between the various objects The very fact that he has but one word limits his capacity for analysis The development of concepts is in large part dependent upon adequate verbal symbols.

For example, in one experiment a subject untrained in color terms is asked to differentiate shades of gray which differ but slightly one from another; only seven can be found between the very lightest and the very darkest one used. When, however, the subjects are taught words to designate the various shades, they can differentiate nine shades of gray through the same range in which previously only seven were differentiated. Through the whole complex process of building up a pattern, we are pushed forward and held back at the same time by the assistance of the language we speak Looking about, one sees a chair, a table, a book, a cigarette These objects are observed as wholes, standing out from the background, partly because, when they are moved about, they move as wholes They are "detachable" from the rest of the environment The objects are also marked off because they have convenient labels. Small children are disgusted by the failure of their parents to present them with different words for quite obviously different things Every hook and bolt with a new turn, a new size, or a new shiny surface is brought to the parent with a request for its name, and the parent can only say, "That's another hook," or "That's another bolt."

The *uses* of objects, not only their appearance, have determined the limits of vocabulary, and there is no doubt that we continue to observe largely in terms of what we can use. Piaget has found that the development of concepts in the thinking of little children is first of all aided by separating objects serving one purpose from those serving another purpose. This agrees with the finding that three-year-olds can define most common nouns in terms of their use, but not in terms of a species-genus classification. "What is a needle?" "A needle is to sew" "What is a horse?" "A horse is to run." It is not until the eighth year that even such a simple generalization as "the horse is an animal" appears.

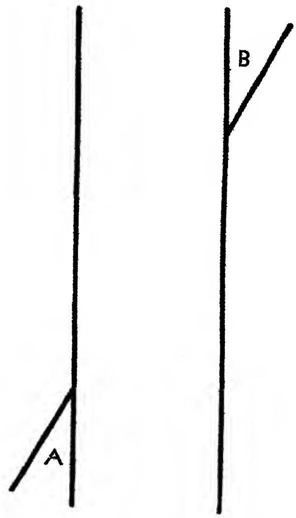


Fig 49—Poggendorf figure.

When perception involves *misinterpretation* the result is an *illusion*.—Illusions are studied by psychologists for the light they throw on the fundamental laws of perception A good illusion with which to begin is the simple Poggendorf figure The slanting lines do not look as if they would meet if prolonged inwards, yet they would do so. In fact, the draftsman drew the slanting broken line without changing the position of his ruler. The illusion is *partly* due to the fact that the eyes do not sweep straight along in one direction. The lines in the upper right-hand corner are shown as if they were grouped around a center at the letter B, and the lines at the lower left-hand corner as if they were concentrated at A. When the eyes swing down and to the left from B, parallel to the slanting line, they come out above the place where the slanting line really emerges.

This explanation in terms of eye movements is of value as far as it goes. It really makes the whole thing too simple, however,

for the effect is not *entirely* due to eye movements. Experiments with a rapid-exposure apparatus which completes an exposure before the eyes have a chance to move show that the illusion is

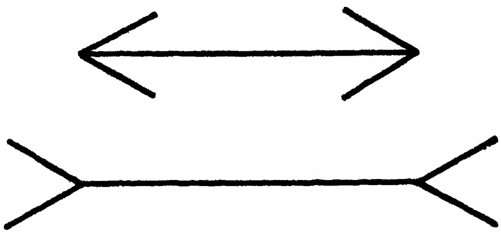


FIG. 50.—Muller-Lyer illusion Which of the horizontal lines is longer? Check your judgment by measuring

still present Many optical illusions depend largely upon the structure and behavior of the internal and external muscles of the eye, but habits of observation are so well ingrained that they

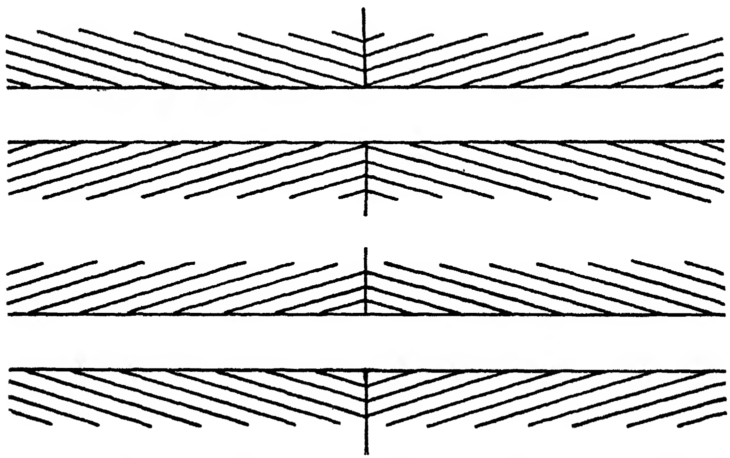


FIG 51 —Hering illusion The horizontal lines are all straight and parallel, but the presence of the oblique lines causes them to appear curved

force us to see in terms of illusions even if, at the time of the experiment, muscular movements are impossible The fact that vertical distances are judged larger than equal horizontal distances is certainly connected with habitual eye movement. On the other

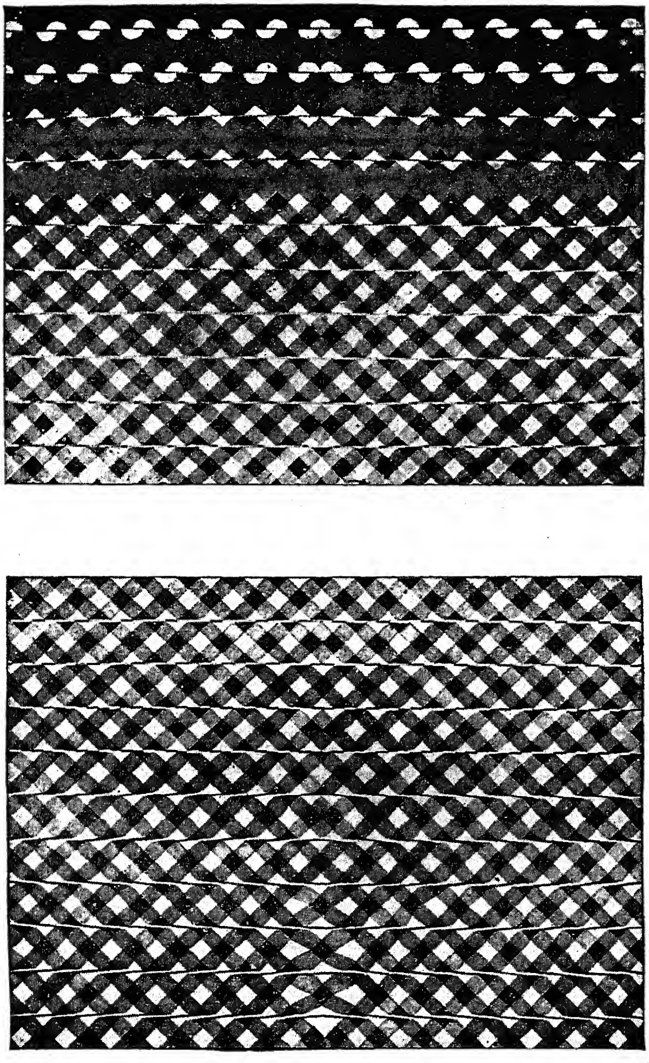


FIG. 52.—Illusion of direction. The horizontal lines are really parallel and straight. Test them with a ruler; they do *not* change their direction in the middle. Study the figures carefully and discover the difference in the elements which compose the two halves of the lines. Careful attention and steady fixation will modify the experience, but the illusion is never completely abolished. From J. Fraser, *Brit. J. Psychol.,* 1908, vol. 2, figures 13 and 14 following p. 320. By courtesy of the editor.

hand, there is much evidence that most of the illusions like those of Poggendorf and Muller-Lyer are due to the way we *group* the lines together. As noted above, we find points within the angles which are centers of reference for the angles, and are really comparing distances between these points; and we do this *whether we move the eyes or not.* Similarly, compact geometrical forms are judged smaller than elongated ones having the same area. All of these have been called "confluxion" illusions The overcoming of the illusion depends largely on practice in breaking up the figure and paying due attention to each part; whether the eyes move seems to be a secondary matter. Compare also Figs. 51 and 52.

Illusions are mostly due to false grouping of sense impressions.—Illusions therefore illustrate and confirm our general principle that perception involves not simply the receiving, but also the *interpretation*, of a stimulus If the lines in any figure are interpreted in such a way that the interpretation would lead to an inefficient response, or would contradict other interpretations which we regard as more dependable, we speak of it as an illusion Illusions, however, are subject to the same psychological laws about the interpretation of sensations which apply to all acts of observation.

Some of the illusions seen with one eye are just as striking as the binocular ones. For example, consider this figure:

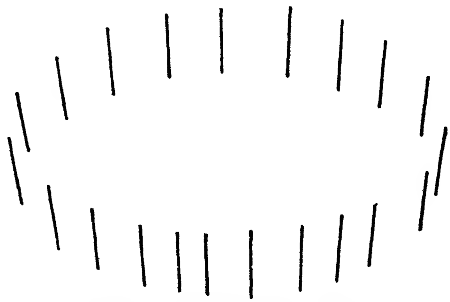


FIG. 53—Ladd-Franklin illusion

If the book is held horizontal at eye level so that the figure is

about six inches away from the eye, the little lines which radiate out will suddenly rise up from the paper and stand erect. Slight sidewise motion of the book will make them all slant as much or as little as one wishes. Here we are dealing with an illusion illustrating the influence of previous experience. Very short vertical

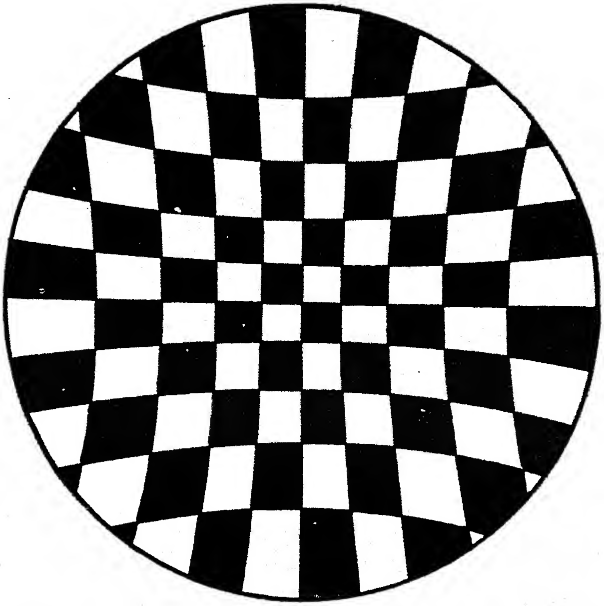


FIG. 54.—Another illusion of monocular vision. Hold the figure about two inches from one eye, close the other, and fixate the center. The lines appear straight and a formal checkerboard pattern appears. The retina is curved and ordinarily when *straight* lines are looked at they really have a *curved* retinal image. We perceive such lines as straight because we have *learned* that they are straight. Here the lines are so curved as to exploit the effect of this habit and we perceive them as straight. From Helmholtz.

lines are a universal aspect of daily experience in dealing with distant horizontal objects. If we have a definite setting or background, we interpret, or "see," these vertical lines as horizontal; if the setting is removed, we see them as vertical. The impressions made on the retina cannot report directly whether a vertical line represents a "really" vertical object or a foreshortening (projection upon the retina) of a line running out horizontally from us

like a road disappearing into the distance. Such monocular illusions show the importance of habits of perceiving based on prolonged experience Fig. 54 shows how, through an experimenter's ingenuity, curved lines may be so drawn as to be seen straight The curvature of the lines in the drawing is such that when held about two inches from one eye, the lines straighten out Curvature of the retina ordinarily causes straight lines to give curved retinal images. We perceive these curved lines on the retina as straight because we have learned that lines of this sort really are straight. If lines are so curved as to take full advantage of this effect of habit, we perceive them as straight.

PERCEPTION OF TIME

Though we scarcely look for the "sense organs of time," the perception of time is an omnipresent fact Nothing seems capable of existing in consciousness without wavering or pulsating to some extent It is of interest to try to find how we gauge the passage of time Very short intervals are judged partly in terms of the actual amount of motion or change we observe We sense the time as longer if more happens in it. In other words, the habit factors are similar to those involved in the gauging of distance by means of haze and intermediate objects, already discussed. Many investigations have been made of the ability to estimate the duration of longer events in the world about one. This is the problem of "filled and unfilled time" Tradition has it that the more we have to do in a given time, the faster the time seems to pass It is empty time that grows heavy on our hands; it is the hour of nothing to do that seems the longest. Thus students underestimated time intervals in which they worked arithmetic problems as compared with intervals in which they had no task to perform Time intervals are also estimated partly in terms of rhythms of strain within the body Heartbeat and respiration are certainly of some importance They do not, however, seem to be our *chief* clues. Time estimates with the breath held are not much

worse than those made under ordinary conditions, and the pulse rate may be sent up and down through a wide range without affecting time estimation very much Probably longer rhythms such as those involved in gastric activity, vascular and glandular changes of a cyclical sort, play some part, but we have little exact knowledge about this. Specially puzzling are the numerous cases of persons who can estimate a given time within a few minutes in a span of several hours without any form of counting. The widespread belief that many persons can wake themselves up at any moment they desire has apparently never been experimentally established, yet there is some evidence to indicate that some people can do so within *a few minutes* of the intended moment

Recent experiments in France and in the United States suggest that the apparent length of time depends directly upon body temperature in a most interesting way. For various subjects and for various time intervals, remarkably clear-cut relation has been established between temperature and the apparent length of a given time interval Patients with a fever of four or five degrees guess the amount of time which has passed since a given signal The higher the temperature, the more rapidly time seems to pass. This fits in well with known physiological facts about the way in which the chemical changes in the body affect the nervous system. Important as this physiological fact is, the estimation of time intervals is of course greatly affected by habits, interests and social conditions

Perception of time illustrates the general principles of grouping and interpretation.—If a time interval between two light flashes, X and Y, is to be judged, it seems to expand if a third flash A is shown before the first or after the second. The subject seems to be confused by the attempt to group the stimulus objects together, as in the Müller-Lyer illusion (page 186). The judgment desired is of the time XY in these two cases:

	A X——Y	X——Y A
The actual judgment is:	X———Y	X———Y

This time illusion seems to be one more case of a principle we have mentioned before, a tendency to group separate stimuli and to treat a whole group as if it were simply one case having the characteristics of an average or middle element in the series Just as the eye in the arrow illusion takes in the whole thing as a lump, so to speak, and actually compares the distance between the two centers of reference, other illusions result from the tendency to group and to treat *as wholes* a number of items which really call for analysis and isolation. Even in the perception of time the introduction of intervening flashes of light between two stimuli makes the interval seem far longer than it is; and the presentation of other light flashes, shortly before the interval to be gauged, produces the kind of illusion that would result from taking as a starting point an instant intermediate between the beginning of the experimental interval and the preceding flash This study shows the variety of ways in which time may be said to undergo apparent expansion as a result of failure to isolate a relevant from an irrelevant stimulus.

These studies of the apparent length of filled and unfilled time also throw light on the way in which space and temporal duration may be confused. Another instance of the same thing appears in the distortion of estimates of space by persons who have taken the drug hashish. This drug profoundly alters the time sense, it makes a moment seem like an hour and makes a brief act like climbing a staircase seem interminable. The space which takes so long to traverse seems, in this case, of immense magnitude. There are many other instances of this. For example, if two lights are shown simultaneously, the one toward which we are looking seems to come on first; small objects presented simultaneously in a spatial field seem, under some experimental conditions, to appear successively Thus, we use time in judging space and space in judging time.

Another interesting aspect of time perception is the attitude toward the future. The future seems definitely less "real" the more remote it is. Experimenters have asked their subjects whether they

would rather have $5 right now or $5000 ten years from now, and have found that to many subjects "ten years from now" means practically nothing For little children the remote future might be said not to exist, and the curves for adults show that it has much less reality for most people than is implied in our penal system with its ten-, twenty-, and fifty-year sentences.

SUMMARY

Perception means interpretation of sense impressions This interpretation depends upon past experiences and present attitudes In order to interpret we must organize and make a whole out of what is presented to the senses We cannot do this until we have learned how to analyze sense impressions. Perception therefore shows three normal stages of development: (1) the meaningless, unanalyzed whole; (2) analysis of this whole, permitting the appearance of separate sensory elements; (3) synthesis of these sensory elements into a new integrated pattern, a "percept" Adult subjects pass through these stages when confronted with a new object, and children seem to pass through these same stages in learning to perceive the world. The visual perception of space illustrates the synthesis and organization of sensory impressions. Our interpretation of size, distance, etc, depends on many cues from the eye muscles, etc Even though the retina only reports two dimensions, we learn to see in three dimensions because we have learned to use a three-dimensional world, the *use* of the muscles and the sensations consequently received from the muscles give a context by which to interpret the two-dimensional impression on the retina. Illusions are false interpretations based on the misuse of past experiences, especially the wrong grouping of sense impressions. Study of perception of time also shows how we perceive in terms of our own individual experiences and how our habits of grouping impressions determine what we shall perceive

REFERENCES

Garrett, H. E, *Great Experiments in Psychology*, 1930, Chapter XIII
Koffka, K., *The Growth of the Mind*, 1924
Ladd, G. T, and Woodworth, R S., *Elements of Physiological Psychology*, 1911, Part II, Chapters IV, V, VI.
Warren, H. C, and Carmichael, L, *Elements of Human Psychology* (rev. ed), 1930, Chapter VII.

PROBLEMS

1. Compare the reactions of a two-year-old and a four-year-old to any new strange object What differences in the processes of analysis or interpretation of the new object can you observe?
2. Look at any book containing modern paintings, pick out the one that looks least like anything you ever saw before Look at it for three minutes as you would ordinarily look at a new picture that you were just getting acquainted with. Write down, in retrospect, what happened during those three minutes. What facts or principles of perception or vision that you have learned help you to understand what happened during those three minutes?
3. Since all the "sources of illusion" exist abundantly in everyday life, how is it that we can get along without being grossly misled by our senses?

CHAPTER XI

PERCEPTION AND THE NERVOUS SYSTEM

SINCE all parts of the body have their own specialized tasks, we may expect the cells of the nervous system to show specialization. They are adapted to serve the function of swift conduction; they have also undergone further specialization through which they have become limited to *certain kinds* of service within this general field. The "central nervous system" includes the brain and spinal cord; the "peripheral nervous system" comprises the incoming (sensory) nerve fibers and the outgoing (motor) fibers; the "autonomic nervous system" has centers lying outside the spinal cord and fibers innervating the vital organs, the walls of the arteries and glands, and other structures which are usually not subject to voluntary control We have already discussed the relations between the autonomic nervous system and emotion (see page 72 ff); here we shall be concerned primarily with certain subdivisions of the *central* nervous system which are important in connection with perception. Pages 44-50 may well be reviewed in this connection

Perception depends upon nerve pathways to the brain.— Sense organs, when aroused by stimulation, excite the sensory nerve fibers directly connected with them.[1]

[1] For the student who is acquainted with chemistry this further note may be of interest Nerve fibers have very thin membranes As molecules break up inside the fibers, positive ions pass out and remain on the outside of the membranes, while negative ions balance them within the membranes Stimulation of the nerve fiber means destruction of this balance and a consequent wave of depolarization which sweeps along to the end of the fiber. When the impulse arrives at the synapse, transmission is effected by some mechanism in the second nerve cell, and it seems probable that the physics and chemistry of the receiving terminals are similar to those of the nerve fiber If so, the process at the synapse might be regarded merely as a special case of the principle of depolarization In other words, there would not need to be any special laws related to the conduction of an impulse across the

When a nerve approaches the spinal cord, the nerve splits in two, all the incoming or sensory fibers passing into a branch which enters the spinal cord from behind; the outgoing fibers proceed from the forward side of the cord. Quite close to the spinal cord each nerve is seen to consist of two bundles. The afferent fibers, those which are going into the spinal cord, are all grouped together The efferent fibers, those which are going out, are grouped together in another main bundle A little farther away

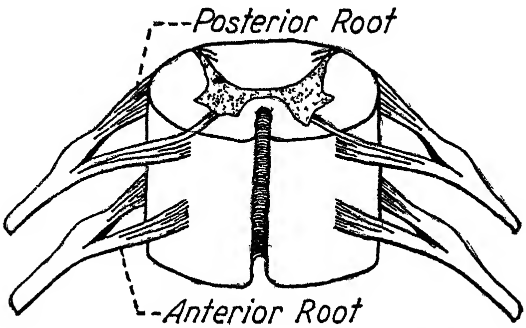


FIG. 55—Spinal nerves in relation to spinal cord The fibers of the two bundles approaching the spinal cord are *not* random groupings Those fibers entering the cord through the posterior root are the sensory nerves, the fibers carrying impulses *in*. The outgoing fibers, the effector nerves carrying impulses *out* from the spinal cord, leave from the forward side, the anterior root

from the cord the two bundles are seen to join. This does not mean that there are any fibers which conduct in both directions. The nerve is a bundle somewhat like a cable containing some fibers headed in one direction and some headed in the other direction. It is only when the nerve comes close to the spinal cord that the fibers serving incoming messages and those serving outgoing messages are grouped into two separate bundles

The incoming fibers find their way into vertical ascending tracts. They are grouped and regrouped; the nerves near the shoulders, for example, deliver their "pain" fibers at a point permitting them

synapse which would be fundamentally different from laws relating to ordinary conduction in the nerve fiber. Under ordinary conditions, the nerve fiber is excited by depolarization.

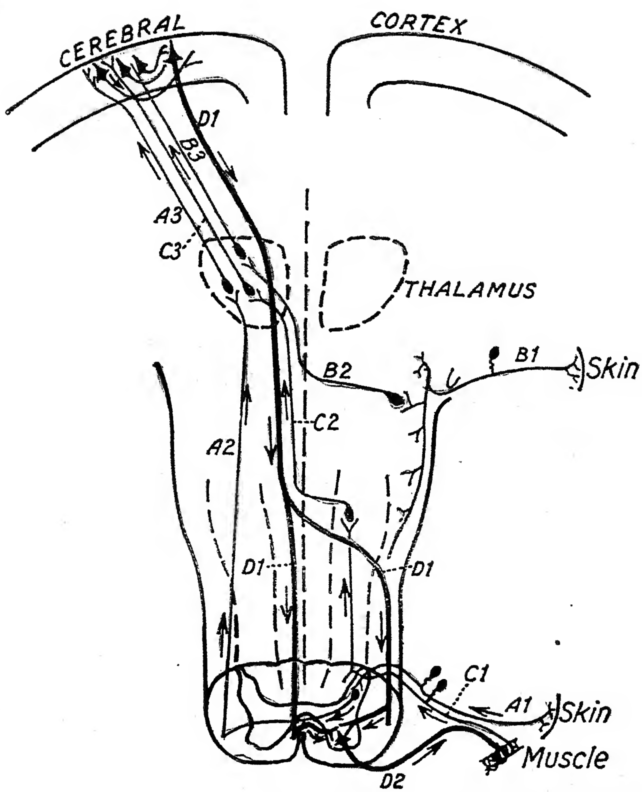


FIG. 56.—The brain stem and its relation to the chief connections between the spinal cord and the cerebral cortex.

Ascending tracts, the incoming fibers:

A1, A2, A3 is the chief pathway for impulses of touch, pain and temperature.

B1, B2, B3 is the pathway for impulses from the skin of the head.

C1, C2, C3 represents the path from the muscles to the cortex.

Descending tracts, the outgoing fibers:

D1, D2 represents the "pyramidal tract" passing down from the cortex and a motor neurone from the spinal cord out to a muscle. This is a common descending pathway for many of the impulses coming up the ascending fibers.

From C. J. Herrick, *An Introduction to Neurology,* 5th ed., W. B. Saunders Company, p. 162. By courtesy of the publishers.

to group themselves with fibers serving the same purpose from regions lower down Other tracts of fibers serve the muscle sense; persons suffering from injury to these tracts lose the sense of position of the muscles These sensory tracts pass upwards until they come to that lower part of the brain which is called the brain stem (cf page 81). This is really a mere continuation of the spinal cord within the skull cavity. Its anatomy and physiology are like those of the spinal cord, rather than like those of the overarching hemispheres of the brain which lie above it. In the brain stem the tracts serving separate sensory functions can still be made out.

There are brain centers for the different sensory functions.—Incoming fibers from muscles terminate in the medulla, low in the brain stem, whence the fibers of a second relay of nerve cells take up the impulse and send it forward. When the forward end of the brain stem is reached, in the part called the thalamus, a third relay is called into action; and this third group of nerve cells sends its fibers up into the "general sense" area, labeled "tactile & muscle sense" in Fig 58. Figs 57 and 58, studied together, will help to make these relations clear. As far as we know, actual consciousness depends upon the arrival at this last region, a region which is called, on account of the way in which the surface of the brain is spread out, a "sensory projection" area; the fibers spread out fanwise as shown in Fig 57. At least three relays of nerve cells, therefore, are required to get an impulse from the muscles to the brain centers. Nerve fibers serving warmth, cold, touch, and pain, pass upward in the same general way, with the difference that the fibers from the skin transmit their message only as far as the gray matter of the spinal cord (cf. Figs 56 and 57), the second relay being required to take the impulse on up to the thalamus In this case, junction is also made in the thalamus. In fact, *all* fibers serving the general senses make connections in the thalamus, with new fibers extending to the surface of the brain

Association fibers connect different parts of the brain.—When the fibers reporting muscular sensations, or warmth, cold,

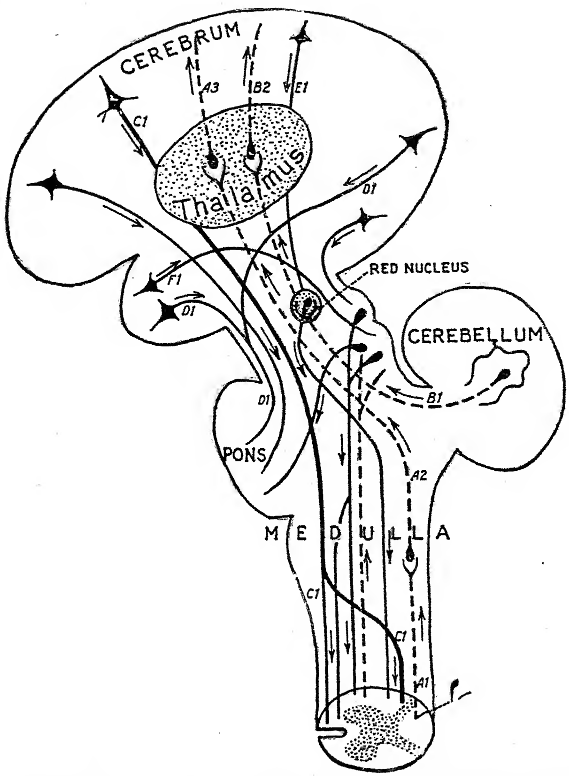


FIG. 57.—Ascending and descending tracts. Note the function of the thalamus as a relay center (the red nucleus is another relay center). The interconnection of the various parts of the brain is shown, but the dynamics of brain action is far from simple, and the drawing oversimplifies the connections.

Ascending tracts (broken lines):

A1, A2, A3 show the course of an impulse from the muscles.

B1, B2 show the connection between the cerebellum and the cerebrum (the cerebellum helps to maintain equilibrium).

Descending tracts (solid lines):

C1 is the pyramidal tract, the main descending pathway, going directly from the cortex to the spinal cord.

Other tracts from the cortex, *D1, E1* and *F1*, make connections with various lower centers in the brain stem.

Perception and the performance of skilled acts involve these, and even more, cooperating nerve structures.

From E. Villiger, *Brain and Spinal Cord,* W. Engelmann and J. B. Lippincott Co., p. 152. By courtesy of the publishers.

touch, or pain, get to the surface or "cortex" of the brain, and the cells of the general sense area are excited, new impulses are propagated in various directions within the brain. Both by tracing the fibers and by electrical stimulation of them, we know that the spread of impulses within the brain cortex is exceedingly complicated. There are literally millions of fibers whose business it is

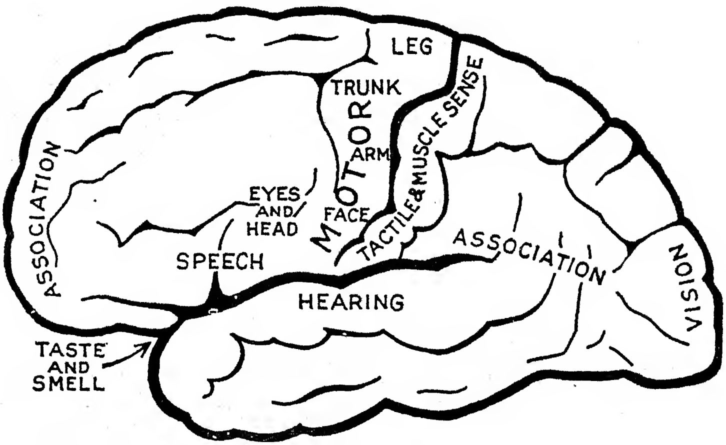


FIG. 58.—Diagram of the left cerebral hemisphere. This figure shows the general location of centers in the brain cortex. Note the closeness of the motor and the sensory regions in the middle of the diagram. The heavy vertical line separating "motor" from "tactile and muscle sense" is the fissure of Rolando. There is still some doubt about the boundaries of some of the localizations shown. From Bainbridge and Menzies, *Essentials of Physiology*, 7th ed., Longmans, Green & Co., p. 299. By courtesy of the publishers.

to relay impulses from one part of the cortex to another, without needing to follow a roundabout path through the lower centers. These fibers leaving the general sense area include some which find their way forward (apparently making at least one synaptic junction on the way) and result in excitation of the big "pyramidal cells" in front of the fissure of Rolando; see the region marked "motor" in Fig. 58. (The fissure of Rolando is the *vertical* black line in the middle.) From these pyramidal cells, fibers pass down through the brain stem into the spinal cord, making synaptic connections within the gray matter of the cord and exciting motor

neurones which lead to the muscles. Cf. the lines marked C1 in Fig. 57.

This is an over-simplified account, for much more than this happens; and it is doubtful whether this account bears any closer relation to the *whole* of what happens in a voluntary act than a skeleton does to a living body. For one thing, there are at least two, and probably several other, brain centers which operate with the pyramidal cells in producing voluntary movements Complete destruction of the motor area on both sides causes *temporary* paralysis in dogs and in monkeys, but the animals regain their lost locomotion and even a high degree of skill; there must be other centers which exercise motor control. Monkeys on whom this operation has been performed can learn quite intricate manipulations of latches and the other fastenings of puzzle-boxes which are so often used to test their motor skill Even an isolated voluntary response to a simple stimulus is of great complexity and involves many centers.

Thus far we have considered the functions served by the skin and muscles. We must next consider the "special senses," sight, hearing, taste, and smell. All of these depend upon relays of nerve fibers; that is, the impulses, instead of being delivered directly from the sense organ to the brain cortex, must make synaptic connections.

In the case of hearing, for example, the fibers which leave the inner ear make a synaptic connection before they have gone any appreciable distance. The second relay carries the message to little bodies which are near (and functionally a part of) the thalamus, and the third relay goes to the auditory center in the temporal lobe The case of vision is even more complicated. Not only are there more relays, but the fact that the two eyes converge upon the same object and require a mechanism for the perception of the thing as one rather than two, necessitates a more complex redistribution of fibers. The fibers reaching other little bodies (functionally a part of the thalamus) make connections like those made in transmitting the auditory impulses, and a final relay con-

ducts from this point to the visual center in the back of the head. Compare the centers for sight and hearing in Fig. 58.

In this rough sketch, the idea of localization of sensory functions in the brain has been stated without argument; but it is important to make clear just what we know and what we do not know with regard to such localization. Removal of the auditory centers in monkeys, apes, or men makes them permanently deaf, and no amount of reeducation restores the function in any degree. Destruction of the relatively small visual area makes them blind. Among some lower mammals, and probably in general among lower vertebrates—fishes, amphibians, and reptiles—loss of special sense centers causes much less trouble. Even rats which have learned a discrimination habit based upon recognition of the difference between light and darkness show, after complete removal of the posterior third of the brain, capacity to acquire this discrimination habit again It is possible that greater specialization of functions within the brain is one of the prices paid for superior specialization of intellectual capacities in general. However that may be, serious injuries at a distance from the visual area occur in great number without causing blindness, for example, in war time; but if the bullet destroys the narrowly circumscribed visual area, sight is at an end. In view of the great amount of clinical material on human beings and experimental material on monkeys, the definite localization of some sense functions in specific areas of the brain is clear. This statement holds for seeing, hearing, the general sense area, and for smell; it cannot be proved for taste, the center for which is not known (it is probably adjacent to the smell center)

On the other hand, we have no such confidence with regard to specialized regions for particular *motor* capacities It is true that many experimenters have found precise localization of certain functions within various parts of the primary motor area shown in Fig 58 The farther down we go on this map of the brain, the nearer we come to the centers which govern the front end of the animal, so that the face muscles are stimulated by a contact at the very lowest edge of the area. This primary motor area, how-

ever, is not identical for all animals of one species; its outline even varies somewhat from day to day in the same animal; and in some reported cases, a point which produces one movement one day produces a slightly or completely different movement on another day. This is what we should expect in view of the complicated spreading of fibers already mentioned, for the movement is probably elicited not directly by the electrical stimulation but by a complicated brain pattern which this electrical stimulation sets in action. It is practically certain from the animal experiments, as well as from common clinical observation of human beings with tremors, paralysis, and other difficulties in carrying out skilled movements, that the pattern involved in voluntary activity is complex enough to justify the expression that "the brain acts as a whole" At least, a large part of the brain seems to be involved in those skilled acts in which long and specialized training, as well as close attention, is involved

Disorders of perception show the importance of connections made by association fibers.—The experimental studies of perception have already shown us that we perceive things not as they are "objectively," but as they have to be seen by creatures constructed and trained as we are. Let the mechanism upon which the training has been expended be injured or upset, and we see things differently. We perceive an almost indefinite variety of distortions or exaggerations of what we should "normally" perceive. The importance of training comes out nicely in the case of "aphasia." Aphasia is a disorder in the understanding of words or in the use of words, resulting from brain injury The injury destroys the physical basis for association between words and thus may suddenly remove the effects of long language training Some patients suffering from aphasia can name the letters in a book and can talk as well as ever, but cannot read the words. Some patients can even spell out the words while looking at the book or without its aid, and yet fail to recognize the visual pattern of the words in print. This is because perception is a truly integrative task There is a genuine distinction between mere *sensory* impressions which

the printed page makes and those *perceptual* responses involved in recognizing or understanding the words as wholes

Of equal interest are the cases in which separate sounds are heard and correctly named, but in which words as wholes are lost This seems a bit spooky stated in its abstract form, and one may be incredulous on hearing of persons who, though thoroughly familiar with a foreign language, suddenly cease to have any understanding of it; yet probably most readers, while sleepy or absent-minded, have had the experience of accurately sensing various elements of a conversation without grasping the meaning of the words; let one be sleepy enough and even the simple words of a conversation are nothing but noise. All of the more dramatic phenomena of aphasia, as Franz has pointed out, have close parallels in everyday experience What bothers the aphasia patient bothers every one of us to a minor degree.

Motor aphasia is the loss of ability to say words appropriate to one's meaning. As a result of a stroke involving cerebral hemorrhage or after a brain injury, a man may lose the capacity to find words for what he wants to say. Franz describes a case of an architect who was working beside a building when a brick falling from a great height struck the upper left surface of his head After operation and recovery from shock, the patient was found to have reasonably good understanding of his situation; he knew in a general way where he was and in what plight he found himself, but he retained only five words—yes, no, and three exclamations. By a process of long training, it was possible to build up a vocabulary of several hundred words. The complexity of the processes of association is suggested by the fact that when Franz showed him the picture of a hen, repeating the word hen slowly about thirty times, and then later showed the picture, demanding its name, the patient volunteered egg, chicken, duck, turkey, a series of related terms, though unable to give the word on which he had been drilled Physical condition, including emotional excitement, affects the ability to recall and organize words in such a case, just as it does in everyday life. If all circumstances are favorable, the regaining of a large part of one's previous vocabu-

lary is possible, though important fragments of brain matter are permanently gone.

Similar to this failure in speech is the failure in writing, *agraphia*, in which the separate movements involved in writing are still possible, but the necessary coordination is lacking In *sensory aphasia*, the perception of wholes is lost, although the parts of an object may still be observed. A person's face may fail to be recognized, or the understanding of a foreign language may suddenly be lost

These cases resulting from brain disorder show that the brain does a great deal more than *register* sense impressions. *Organization* of these impressions is one of its major functions.

Interconnection of the parts of the brain enables it to act in an integrated way.—As to the nature of the brain's work in such organization, we may note that the interlacing fibers connecting the various sense centers with one another, with the motor centers, and with other parts of the brain suggest that a thing loses "meaning" because it loses *connection* with other things Connection of this sort between various parts of the brain is probably the same as connection between the various parts which function in the execution of a skilled motor act; motor patterns are ultimately dependent upon the same kind of cerebral activity as the perceptual patterns. If this is true, all the facts of perception and learning fall under a universal principle; they are all cases of association, and association is a question of brain connection This is a perfectly valid general statement as far as it goes, but it will need to be worked out more fully and supplemented with more specific statements. It is necessary also to remember that large patterns of association may function all at once, and each associative connection may be influenced by all the rest. Starting with the separate connections and working toward the whole is a sensible procedure; but the better we understand the whole, the more clearly shall we understand the way in which the separate associations are formed and combined with other associations

The whole brain is active in the process of perceiving We noted that simple seeing and hearing depend on localized regions; but

the more complex the perceptual process, the more complex is the brain activity, and we should not expect that any complicated visual or auditory process could be entirely unaffected by changes anywhere in the brain. Vision, for example, though depending first of all on the visual center, probably normally involves the whole brain; and this is true of all acts of perception.

Though we have carried the doctrine of localization further than some psychologists do, we must emphasize the fact that there are large masses of brain material which cannot reasonably be suspected of having any precise specialty. The "association areas" make up probably 80 per cent of the brain. Association areas relate the various parts of the brain with one another and with the lower centers, but do not have specific functions which are fixed for a lifetime Destruction of a pathway from the visual center to the auditory center may cause disturbances in association between things seen and the sounds of the words designating them. In some cases of sensory aphasia, it appears that fibers connecting one part of the visual area with another part of the same area have been injured, with the result that, although separate reception of the parts remains, the thing as a whole has lost its meaning. These represent "pure" cases Most brain injuries and brain diseases cause irregular and scattered destruction; and for every case of clear-cut and specific loss of just one function, there are hundreds of cases of disorganization of association in a larger and less clearly definable way. Many brain patterns are disturbed simultaneously, and in some cases, such as those of senility, the entire brain may be disorganized. The pure cases, however, help greatly in understanding the general principles of brain action.

SUMMARY

When sense organs have been stimulated, the sensory nerve fibers lead to the central nervous system There are different pathways for nerve fibers serving different functions Those fibers serving the skin senses follow paths leading to the general sense area

behind the fissure of Rolando. The fibers serving vision pass to the occipital lobe, while those serving hearing pass to the temporal lobe. In front of the fissure of Rolando there are nerve cells from which pathways start downwards leading to the execution of movements All parts of the brain are interconnected by association fibers, which connect sensory areas with one another and with the motor areas. Excitement of an isolated sense center would not lead to perception, since perception or interpretation of stimuli requires that each stimulus be associated with others When the association fibers are injured, sense impressions often lose their meaning, as in cases of sensory aphasia. The fact that perception is an act of integration goes hand in hand with the fact that the nervous system acts in an integrated way.

REFERENCES

Herrick, C. J, *Introduction to Neurology* (5th ed), 1931, Chapters XIX, XX, XXI.

Ladd, G T., and Woodworth, R S , *Elements of Physiological Psychology*, 1911, Part I, Chapters IX, X, XI.

Lickley, J D , *The Nervous System* (new ed), 1931.

Piéron, H., *Thought and the Brain*, 1927.

PROBLEMS

1. List the ways in which the nervous system seems to resemble a telephone system, and the ways in which it does not
2. Would it be legitimate to compare the "development of perception" with the "development of the nervous system in the individual," working out a generalization that *all* human development is from the general to the specific? Why, or why not?
3. Persons who have taken the drug mescal report that for several hours a procession of highly organized, often meaningful, hallucinations results What light does this throw upon the way in which the nervous system works?
4. Do you find any basis in psychological evidence for the Hindu idea that the external world is illusion—that it is a product of the minds of men?

CHAPTER XII

ATTENTION AND DISCRIMINATION

In attending, we select from the environment.—In all of our discussion of perception it has been assumed that we respond to the whole world about us. The process of perception involves grouping and integrating the elements upon which our sense organs report to us. Obviously, however, we do more than take in impressions and group them in doing so. We *select* from what is presented. Even the little child selects A pain or a toy commands more attention than an object which gives neither satisfaction nor distress We respond to some items in our surroundings more definitely than we do to others, giving an explicit and definite response which is clear even to a casual observer, but we are obviously indifferent to or even ignorant of much which is present at the same time as part of the stimulus world. The man absorbed in his own daydream or hobby fails to hear what we say. We remark that he is "absent-minded" In other words, he is attending to something other than what we are saying The discussion of perception has not explained how the man is able to sit there in our presence bombarded by our words, yet not hearing the words. The process by which we bring into focus certain things that are going on outside us, the process by which we select from and emphasize specific parts of the world, is attention.

In general, the first main fact of attention is the differentiation of the world into a foreground and a background, a world selected and a world rejected—often called "figure and ground." Look at this sketch for a few seconds, noting how the two figures alternate. What is "figure" at one moment is merely "ground" at the next moment.

Everything perceived is selected from a realm of things which

might be perceived. Such simple visual factors as those presented in the figure are instances of the principle of selection. The sense organs are themselves selective. Many of the sense organs of animals are movable. The selective function is obvious in the motion of the nose and the breathing movements called sniffing,

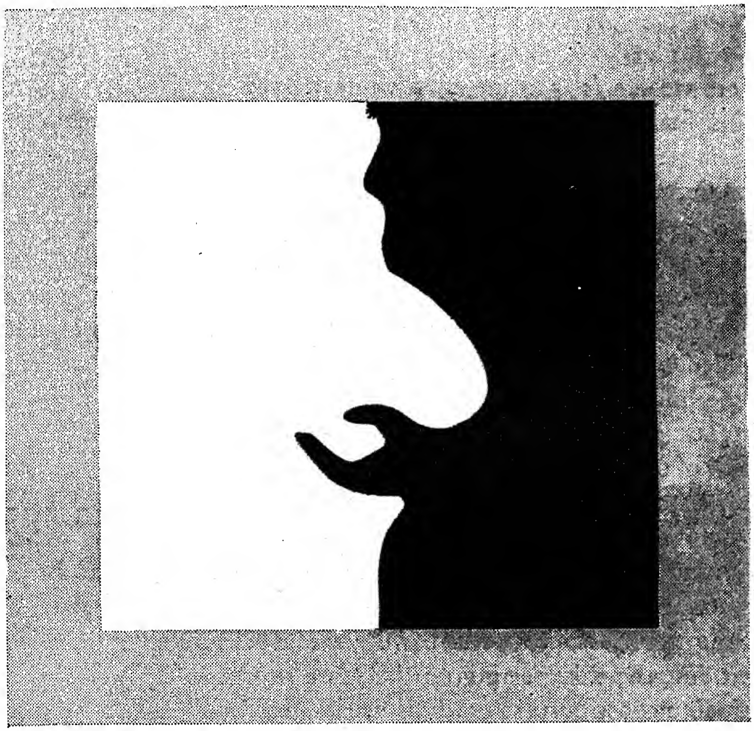


FIG. 59.—Modified from E. Rubin.

at which many animals are more expert than man and upon which, for example, a bloodhound depends; in the shift in position of the ears of which horses make good use in hearing distant sounds; and in the movement of the eyeballs in which no creature is more skilled than man. The physical energy from the stimulus thus gets in its work upon the receiving organs.

Consciousness may be divided into "focus" and "fringe."

—From the point of view of what is most effective in producing motor response, as well as from the point of view of what takes the most prominent place in consciousness, there is a further selective function to be considered, beyond the mere moving of the sense organs. Let the eyes be fixed on the cross in the figure below.

+ ★

Here we can *look at* the cross while we are *attending to* the star This function of attention is therefore not simply a matter of eye movement, just as our varying attention to sounds about us is not simply a matter of head movement. Other muscles than those which help to move the sense organs are involved, and it is likely that what is known to consciousness as attention is related also to many complicated activities both in the muscles and in the brain

When we say that not everything present to the senses is attended to, we imply that there is relatively clear awareness of some things and relatively obscure awareness of others. I have in the last few moments been very clearly aware of the paper in front of me, but only vaguely aware of sounds in the street outside The distinction between clearness and unclearness of consciousness is emphasized by the terms *focus* and *fringe*. The focus of consciousness includes only those elements to which we are directly responding. A vast outer zone is made up of things which are acting upon us but to which we are not attending. A third type of thing, the thing acting on the sense organs but not forcing its way into consciousness *at all*, is usually said to be in a zone so far out that it is "beneath the threshold of consciousness." A slight change, however, as in the pressure of a shoe or the force of the wind, may cause the impressions which were beneath the threshold to force themselves into consciousness From the point of view of introspection, the difference between what holds the center of attention and what gets into consciousness but not into the center of attention is a difference in clearness This use of the term "clearness" is not to be confused with mere definiteness of outline. We may be giving full attention to the haze in a landscape or

to the indistinct sound coming from a telephone in an adjoining room. The letters of the title of a book may be large, clear, and well-defined, though our awareness of those letters at a given time may be obscure or dim. Attention is therefore, from the introspective point of view, a question of focusing our impressions so as to give them this special kind of clearness

The span of apprehension is the number of objects which can enter the focus so as to be grasped at once.—The *focus* of consciousness is always an organized whole, a single field standing off in contrast to all that is not attended to An old and much explored problem of psychology concerns the number of units which may be taken in by this span of observation Sir William Hamilton threw marbles upon a surface to find how many could be seen at one glance. He found that if the number was not greater than six, the observer could usually tell how many there were. The experiment was crude since the area upon which the marbles were thrown was large, furthermore, the location and grouping of the marbles made the task sometimes easy, sometimes hard All this was made capable of more exact study by the invention and development of the *tachistoscope.* Such contrivances usually depend simply upon gravity. The experimenter causes a card containing letters, numbers, etc, to fall behind the opening in the screen, to remain there a certain interval (usually a small fraction of a second) and then to fall down beneath the slot. Other more complex exposure methods are in use. For most common purposes rather rough timing of the intervals, e.g., in fiftieths of a second, suffices But where the experimenter wishes to know precisely how long it takes a stimulus to get in its work upon the retina before the impulse leads to any visual experience, finer measurements, e g., thousandths of a second, are used. Much precise work has been done on the exposure time required to make possible the perception of color, shape, and so on, or the differentiation between different geometrical shapes, or the naming of different words.

Most of the main outlines of the results on span of apprehension

in the field of sight—for example, the averages and the variations found in persons of different ages and degrees of education—are similar to those obtained in studies of hearing, touching, and other sensory processes. The digit span is an example of a process studied in both vision and audition with basically similar results The problem may be stated: "How many digits may be read aloud in random order at the rate of one digit per second and repeated without error by the subject?" Four-year-old children can on the average repeat four digits correctly; eight-year-olds, five digits; and ten-year-olds, six digits. This bears a definite relation to *mental growth.* The digit span experiment in the field of *vision* is usually carried out by placing a row of digits, an inch or so high, on a horizontal wooden strip; armed with many combinations of digits, running from four to eighteen or twenty items each, the experimenter holds each strip in such a way that the group may all see it; a metronome nearby tells when to lay it down again In order to make visual presentation time comparable to the time used in the auditory experiments, the strip is held up for the number of seconds *equal to the number of digits shown.* If, as is usually the case, the experimenter starts with four digits and works up, he simply increases the time accordingly; or long and short lists may be alternated. With *one second per digit*, the adult span averages about seven. With minimal exposure, four or five letters, or four or five numbers, can be grasped and reported by adults; if the letters are combined into words, these are taken as wholes, and thus twenty or twenty-five letters arranged to make five familiar words can often be grasped.

Systematic experiments of this sort have not been tried with other senses, but there seems reason to believe that the same principles are involved and that the average adult span of apprehension is about the same for sight, hearing, and touch But in comparing individuals it must be noted that a high span of apprehension in sight is not necessarily linked with a high span of apprehension in another sense, e g , hearing We are not dealing so much with a formal power of attention as with highly complex

abilities dependent upon properties of eyes and ears as well as other parts of the body, including the brain.

Apparent *fluctuations* occur in objects whose actual energy value with reference to one's body remains the same. A watch held at some feet from the ear seems to tick now more loudly, now more softly, and if moved far enough, to a point where the ticking is just perceptible, the sound will fade away for a moment and be literally inaudible, and a moment later reappear. If one counts repeatedly during half-minute periods, it will be found that the number of fadings-away and comings-back is usually about the same. Whether or not this is strictly a matter of "fluctuations of attention," it points to a variability in the selective function which has been emphasized here; the body is variable and undependable as a receiving station, just as it is when considered as a delivery center for motor responses to the external world. The experiment just described with the watch ticks can be carried out with good control in the field of vision by the Masson disc; as a wheel revolves a gray line which is just visible keeps disappearing and reappearing

Fluctuation effects of this sort seem to be due in some degree to changes in blood pressure, respiration, and other physical conditions; probably they are not simply shifts in attention, but variations in the *threshold* of the stimulus in these cases We usually measure the threshold when the person is paying as close attention as possible, and it is easy to forget how the threshold varies from moment to moment.

True fluctuations of attention are involved in the shifting of perceptual patterns.—Look steadily at the cube for a half-minute, then at the staircase for the same interval (Fig. 60). Alternation between two ways of seeing such a pattern may take place many times even within such a short interval.

Some of this is due, as is easily tested for oneself, to eye movements, such as are involved in blinking and glancing again quickly as soon as the eyes are open. The fixation point also plays an important part in the control of these shifts This may be brought

out easily in the case of the staircase figure Here some individuals report that the staircase does not shift back and forth but remains for long periods as if sloping down toward the observer. One need only "take hold" of point *C* and imagine it to be given a sharp jerk forward with the fingers; the resulting forward shift in location of point *C* will help in repatterning the whole figure.

It is even possible that the entire phenomenon of attention shift is due to sense-organ adjustments plus muscular adjustments in various parts of the body, but this is improbable.

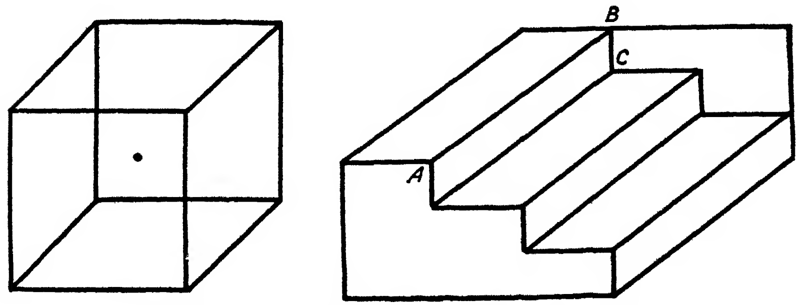


FIG 60—Ambiguous cube and ambiguous staircase figure Each may be seen in two different ways. Fluctuation of the cube continues even after eye movements are reduced by looking steadily at the dot in the center

Habits of attending develop gradually.—Selection among stimuli is at first involuntary, and here we have certain important factors, such as intensity and change, which give certain stimuli an advantage over others. The child's eye caught by two lights is dominated by the brighter one Here "involuntary attention" is but little controlled by internal organic conditions; it is almost entirely at the mercy of the environment. Experience provides that many other stimuli, because of their connection with certain motives or interests, come to be dominant where before they had but little influence. The development of attention from the involuntary to the voluntary stage is in large part a matter of building up habits of response to stimuli which were previously not dominant. The nurse who is roused by rapid breathing in her patient and the miller who wakes up when his mill stops are proverbial

instances of the fact that we attend to things we have learned to select. In other words, selection is itself just as dependent on experience as is any other response of an organism.

In the case of figure and ground we have already noted a number of factors which make a design more likely to be selected as figure. One might make up a list of factors, such as intensity, duration, sharpness of outline, and the like, which in practically all persons serve to make a thing easily selected from the broad general background of experience—in other words, aspects which make us attend to them. The cases we have just described, however, show that to a large degree we have *learned to attend*, and that the habits and interests of the individual are profoundly important. So the teacher and the advertiser, to give but two illustrations, find in what ways rhythm, color, and type in printed matter are generally effective in catching attention; in addition, they study the attention habits of the group they wish to reach. This highly specific character of the habits of attention is important because there is still a tendency to regard general attentiveness as an all-round characteristic of each person In fact, one hears constantly of people who "cannot hold their attention on their work"—as if it made no difference what the work is. Actually, each of us has his own personal habits of attending; and he who wishes to reach us and make us respond must study us as individuals.

But there are limits in such selection and control; there is a degree of intensity of any stimulus beyond which it simply cannot be shut out. In cases such as the flashing of a bright light into the eye or the thrusting of a needle into the hand, there is practically no chance to decide whether the thing is to be attended to or not.

Attention is unitary.—Experiments on the span of apprehension (page 211) find the number of objects attended to at once The phrase "span of attention" is sometimes used to describe this. But since this phrase suggests that attention itself has a span of a certain number of items, it implies that attending is subdivided into a certain number of parts. There is a good deal of evidence

to show that the act of attention, as well as the region of maximal clearness in consciousness, is *unitary*, and not properly described in an arithmetical terminology based on the number of elements noted As Dallenbach has put it, "the span of attention is unity"

It is from this point of view that we may best answer the question as to the possibility of thinking of two things at once. If the two things are integrated, as when we think of white as the opposite of black, the *aspects* of this unitary consciousness may be labeled as black and white, and the relation may be described as a relation of opposition. It is doubtful, however, whether these are distinct "parts" in the geometrical sense of the term. Whenever complex mental wholes are considered, this problem of unity returns. Considered in this way, it is doubtful whether normal people ever think of more than one thing at once Of course, as in playing the piano, automatic activities go on parallel to the conscious activities, or there may be exceedingly rapid alternation from one conscious function to another. But this is not really attending to two things at once.

Nevertheless, among studies of drowsy or semi-sleeping persons, and in a few reports of dreams, there exist cases in which an individual reports a true breaking of consciousness into two parts A letter by Robert Louis Stevenson tells how a horrible drama went on in a dream while another consciousness, running parallel to the dream-consciousness, knew well enough that the thing was unreal—yet could not make the horrible dream-consciousness see it from the same point of view.

It is true that psychological difficulties are involved in admitting this duality of the attentive consciousness, but in the face of cases of this sort we must admit that under special conditions the laws which ordinarily relate to the behavior of the "organism as a whole" do not appear to hold. These cases nevertheless offer evidence that the organism under consideration is in an abnormal state, and confirm us in our belief as to the *normality* of integration or action of the organism as a whole.

We have found various indications that the process of selection, though it is partly a matter of adjustment of the sense organs, is

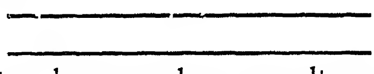
also partly a matter of adjustment of the organism as a whole. We noted that one may *fixate* one thing and *attend to* another. The study of the retinal color zones (page 149) requires, of course, the same distinction between "fixating" and "attending," as do a thousand everyday tasks such as listening to an explanation as one studies a piece of machinery or a biological specimen The ability to do this depends in part on muscular adjustment even in remote parts of the body; habits of attention show themselves in posture, clenching of the hands, tightening of the facial muscles, and so on Probably also there are more complex internal adjustments. Perhaps the thing attended to is the thing which *arouses the most concentrated brain activity*; at all events, a great deal is involved other than mere selection by the sense organs. This is easily shown in those cases of mental disorder in which the sense organs function normally while attention is more disturbed than are most other aspects of the mental life. Abnormal cases of disordered attention, in some of which there is wild, incoherent talk, illustrate the point. Usually in such cases the whole mental life—"perception," "memory," "association," and every activity for which we have a name—is disordered, but this disorder appears most characteristically in the distractibility of the patient, the fact that he is unable to maintain any kind of internal steering process, to hold attention on any one thing. In many cases the cause is known; this kind of disturbance may appear in morphine addiction or chronic alcoholism. In many other cases, however, we are hardly justified in suggesting causes. The point is that attending is not an isolated mental "faculty" or "part" of the mind It is a kind of activity, and it is the organism as a whole which does the attending.

DISCRIMINATION

It is customary to distinguish between acts of perception, on the one hand, and, on the other, the "higher mental process," which includes the process of abstract thinking. Nevertheless, all sorts of transitional problems are found. The separation of higher

from lower is no more than a separation of the complex from the simple, presenting all shades and gradations. The point comes out clearly in the study of the *perception of similarities and differences*—an activity which may be considered almost purely *perceptual*, or as the foundation of all *higher* mental processes.

Discrimination between stimuli depends upon relative intensities rather than absolute intensities.—It was through the exploration of discrimination that modern experimental psychology came into being. At the University at Leipzig nearly a hundred years ago, E. H. Weber undertook a systematic study of the muscle sense. One question that occurred to him was this: If a weight is hefted in the hand and then another weight is hefted and compared with the first, how large must the difference in weight be in order to enable the subject to tell which of the two is heavier? Experimenting with four subjects and using 32 ounces as a standard, together with heavier and lighter comparison weights, Weber found that the judgment was usually right if the comparison weight differed from the standard by an ounce. When using standards only one-eighth as heavy, he found that discrimination seemed to be eight times as good—that is, the subject made no more errors in comparing four with four and one-eighth ounces than he did in comparing thirty-two with thirty-three. He then tried another standard weight, and again found that the difference which was required to make possible a right comparison was not an absolute quantity, but simply a fraction showing the ratio of the lighter to the heavier weight—in this case, always about one to thirty. Much interested by these results, he tested the ability of subjects to compare the lengths of horizontal lines, as shown in the figure.



Here, when the two lines are shown simultaneously, a subject is able, with practice, to distinguish 49 from 50 millimeters or 49 from 50 inches. Again a law of comparison seems involved, rather than a law based on absolute magnitudes. Weber laid down the generalization that in comparing any two stimuli of like quality,

the quantitative difference required for correct comparison is a constant fraction of the smaller stimulus (Weber's law).

Moreover, when weights were laid upon the palm of the hand, as the hand rested on a table, the same law held. To be sure, the pressure sense was much less accurate than the muscle sense; one weight had to be about 35 per cent heavier than the other to make discrimination possible. But again this percentage or fraction remained constant, irrespective of the absolute magnitude of the weights used.

Attempts were later made by G. T. Fechner and many others to extend and systematize the whole field of research on the comparison of stimuli by such methods; this field is called *psychophysics*. In optics, for example, delicate measurements have been made, the eye being stimulated by quantities of light so minute that the subject sees no light at all, up to brilliancies which are nearly blinding. When two parts of the visual field are unequally illuminated, how much more light must there be on one side to enable the subject to tell which is brighter? Here the middle range of intensities of light—that is, the range to which we are ordinarily adapted—conforms rather well to the theoretical figures predicted by Weber's law. At low and high intensities, however, the figures diverge greatly from theoretical expectation Intensities of sound have been studied in the same way, with results which seem in close conformity to Weber's law through the middle range, in fact, for the range needed in conversation.

Quite possibly there is a simple biological basis for Weber's law. It may be that all responses tend to go up in a graded series less rapidly than their stimuli go up, so that the bodily response to 30 pounds may really differ no more from the bodily response to 31 pounds than the response to 30 ounces differs from the response to 31 ounces. Bodily response may be considered as increasing arithmetically (e.g, 1, 2, 3, 4, 5, 6) while stimulus intensity increases geometrically (2, 4, 8, 16, 32, 64).

Such mathematical relations hold in other fields than psychology. Each extra gallon of gasoline burned per hour in an airplane engine will not make the same increase in speed; as speed increases

it will take more and more gasoline to add another ten miles per hour Perhaps this kind of mathematical relation appears consistently as an expression of the rate at which inner response increases as a result of external stimulation from noises, or flashes of light, or extremes of temperature.

The psychophysical methods are improved experimental methods for the study of discrimination.—Such studies presuppose that the *difference between two stimuli* necessary to permit discrimination in a given experiment is reasonably *constant.* Yet the same two stimuli presented to the same subject may be correctly compared practically all the time on one day and not more than two-thirds of the time on another day. This makes it hard to tell what the "just noticeable difference" really is. Moreover, there ought to be reasonably consistent results from one subject to another It is not necessary that one subject be as skillful in comparison as another; but if the laws regarding comparison are to have any general validity, the *relative skill* of the subject working with different standard weights ought to remain constant How are we to measure the subject's skill? We cannot reasonably demand that the comparison be made in the right direction one hundred times out of one hundred. On the other hand, it would be made in the right direction by chance alone fifty per cent of the time, so that we must demand a considerably higher percentage of success than that; we must set a *standard of success* which will be the same in all experiments. For this and other reasons, the experimenters in this field have felt the necessity of improving and standardizing their methods, so that all the results from different subjects working under different conditions may be brought into line and seen in perspective.

The method used by Weber described above is called the method of "just noticeable differences"; a method derived from it is called the "method of minimal changes " The subject is asked to compare a varying stimulus with a standard stimulus, and to indicate when the varying stimulus becomes apparently equal to the standard and when it emerges on the other side, definitely distinguishable from the standard For example, with a standard

light before one, a brighter light may be made dimmer until it seems equal to the standard and then definitely less bright. Many determinations are made of the point at which the variable seems to become equal to the standard, and the point at which it again diverges; and the same experiments are made moving the stimulus in the opposite direction Another method, "the method of constant stimuli," works with various stimuli of fixed value, each of which is to be compared a large number of times with the standard. Some of these stimuli equal the standard, others are near enough to the standard so that errors are made nearly half the time, but at least one of the stimuli differs enough so that the percentage of right judgments is 100; the magnitude considered necessary for satisfactory discrimination is the one which gives 75 per cent correct judgments. Curves are worked out showing the decreasing success in estimation as the difference between the two stimuli decreases

In still another method, the "method of average error," the subject himself varies one stimulus and tries to make it equal to the standard. The average amount of his deviation from the right value determines the fineness of his discrimination In general, all these methods, as well as others, give comparable results; they all give results which fit Weber's law fairly well in the middle ranges, but depart widely from it at very high and very low intensities

In the study of discrimination there are other closely related experiments which are not ordinarily classed with psychophysics Thus Weber and others have measured how far apart two visual stimuli have to be in order to be perceived as two; this is a problem in visual "acuity." A single "minute of arc," 1/21600 of the circumference of a circle, seems all that is needed for the average trained observer Other studies in discrimination are numerous; for example, those showing how long a time interval must intervene between two sparks at different points to enable the observer to report which came first (here about .1 second seems sufficient) and how far apart two clicks have to be in order to be heard as

two (.002 second suffices). These studies have not been systematized by psychophysical methods.

Methods like the psychophysical methods used with human beings have also been used with animals; e.g., the honeybee's

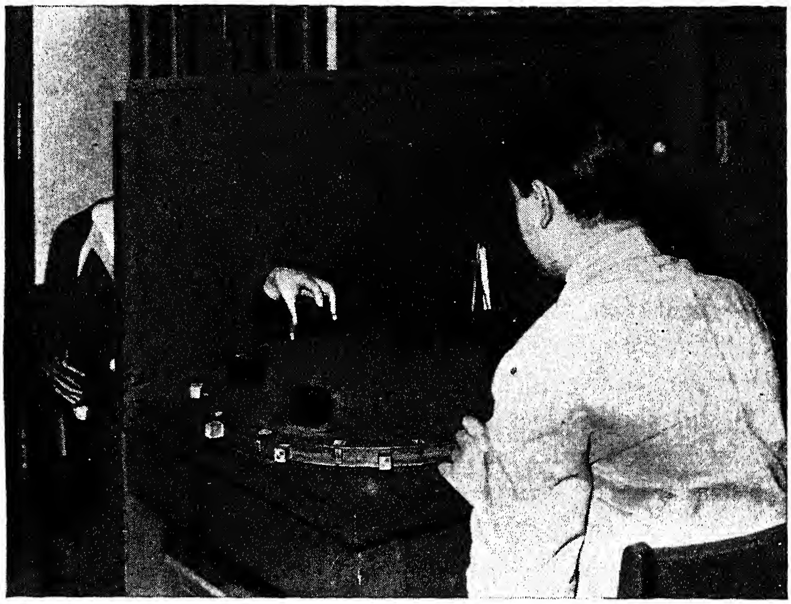


FIG. 61.—Comparison of lifted weights. In time with the beating of the metronome, by turning the revolving table on which the weights are supported, the experimenter presents stimuli, in a prearranged order, similar in all respects except weight, to the subject who is screened from the stimuli and whose arm is held in a fixed rest. The subject thus barred from the use of visual cues, with restricted arm movements, and with no variable other than weight, may be called on to report whether the lifted weight is "heavier than," "lighter than," or "equal to" the stimulus lifted just before.

brightness discrimination has been compared with that of human beings. Pavlov and his pupils in Russia have tested dogs for discrimination of tone. Food was given to these dogs when they heard a tuning fork which was sounding at 256 double vibrations per second, and the flow of saliva was measured. Then the variations in the flow of saliva were measured as the pitch varied above and below 256, the animal not being fed except when the tone was

exactly 256. This is a "discrimination" method intended to tell how well the dog can discriminate between tones. Similar studies have been made with color discrimination in animals, showing that dogs, cats, and most other mammals are color-blind, though excellent in discrimination of brightness.

Measurement by relative position permits quantitative grading of stimuli even when the stimuli cannot be measured.—Cattell made up over two hundred gray strips, each differing in brightness so slightly from the next that many errors were made in comparing them. Subjects could arrange these grays in sequence with some degree of skill; when a large number of subjects work at such a task the average of their results is almost identical with the true order of brightness. Cattell saw that the psychology of discrimination offers a clue to the measurement of many important things which cannot be measured by a physical instrument. This procedure is called "measurement by relative position." When two hundred students are asked to arrange ten weights in order of magnitude, few make high scores, but the *average* score is in almost perfect agreement with the true order Why should not the same method be resorted to when degree of excellence in handwriting, degree of eminence of scientific men, or any other "subjective" issue is involved? Groups of students acting in this way as judges do actually agree with one another exceedingly well if the groups of judges are large enough. Scales for measurement of handwriting have recently been made up, and even for English composition. We do not, of course, pretend to measure the highest achievements of the literary imagination, but only commonplace things with which all of us deal in everyday life. Fig. 62, which shows the methods used at Minnesota for classifying degrees of excellence in mechanical drawing, will show what is meant by a "rating scale." Methods of this sort are much better than sheer measurements with a ruler, which might be more "objective" but would tell much less about the actual quality of the work turned out. In some cases it is possible to prove by subsequent developments (work done later and measured in an objective way, like output and earnings) that in experts' hands

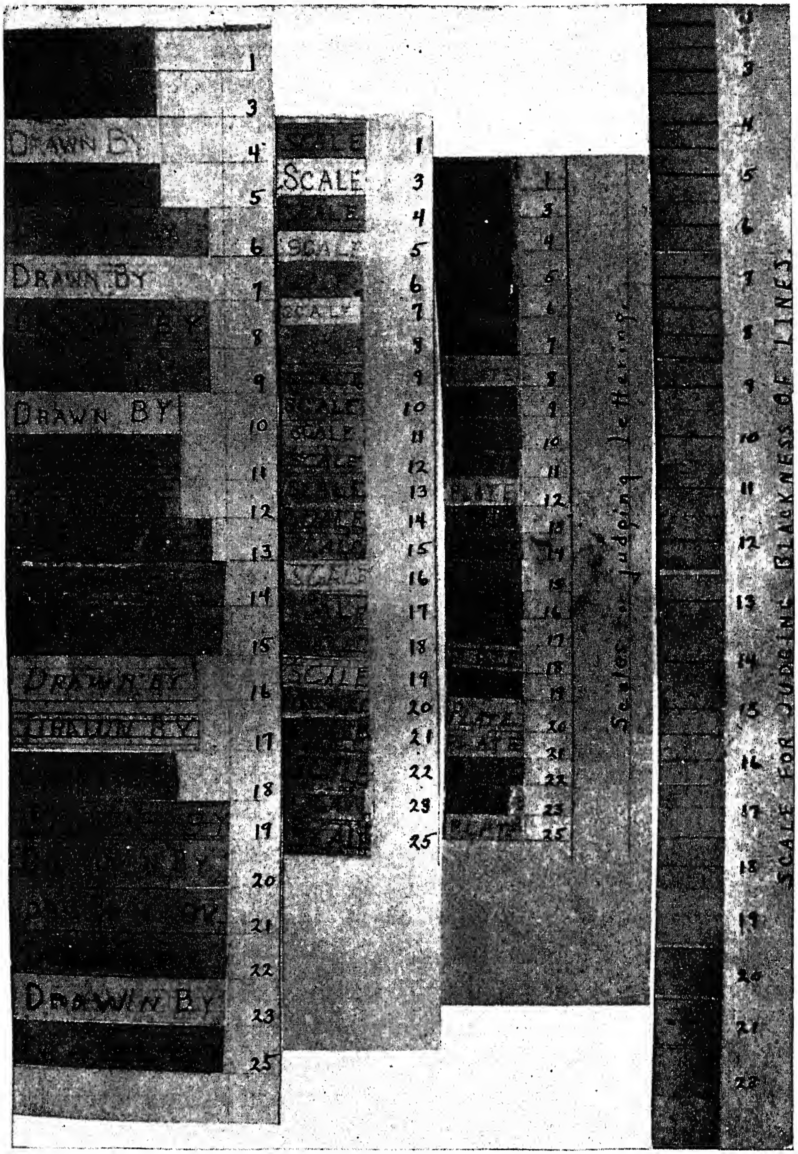


FIG. 62.—Scale for measuring the quality of work in mechanical drawing. This is a sample of the way a definite numerical score can be assigned to the quality of work, a score which will have about the same meaning no matter who does the scoring. To the right is the scale for measuring the blackness of the lines used. The

these ratings are quite dependable In other words, *discrimination* is not only a matter for experimental study, but is itself a *method* of measuring many other psychological processes.

SUMMARY

An organism selects from its environment certain things to become aware of; and from among the things of which it is aware, it selects some for specially *clear* awareness Both kinds of selection shift rapidly from moment to moment. What is in the fringe of consciousness at one moment may be in the focus the next moment The focus may take in six or seven numbers, letters, etc., but the act of focusing is a unitary act of selection from the environment. The organism does not really attend to two things at once; it must integrate what it selects. Learning how to attend is largely a matter of learning how to select, group and organize particular kinds of sense impressions

Discrimination, as studied by the psychophysical methods, depends on relative intensities rather than absolute intensities (Weber's law) Measurement by relative position takes advantage of this fact, and regards "just noticeable differences," revealed by a large number of judges, as a basis for constructing a scale to measure qualitative differences.

REFERENCES

Garrett, H E, *Great Experiments in Psychology*, 1930, Chapter XV.
Ladd, G T., and Woodworth, R. S, *Elements of Physiological Psychology*, 1911, Part II, Chapter III
Titchener, E B, *A Text-book of Psychology*, 1910, pp. 265-302

other three scales are for judging the quality of the lettering used in printing the words "drawn by," "scale," and "plate." The work being rated is held alongside the scale and the sample corresponding to it is selected. Next to these samples is a number indicating their value Such values are gotten after long preliminary comparison of samples, but once arrived at they can be used by everyone They are much more significant than marks assigned without such aid because they express the same thing for all who rate such work From D G Paterson, R M Elliott, L D Anderson, H A Toops, and E Heidbreder, *Minnesota Mechanical Ability Tests*, Univ of Minnesota Press, facing p. 195. By courtesy of the publishers.

PROBLEMS

1. In connection with *discrimination* we referred to "trained" observers In what does the training actually consist? How can one be sure that the training is not *mistraining?* Would not results for ordinary observers be psychologically more significant?
2. Answer the same problem in relation to attention. If your answer differs, explain why.
3. In what way does the skill of a surgeon or an artist depend on trained habits of attention?
4. What are the commonest devices for securing the attention (a) of a small child, (b) of a bored person, (c) of a political gathering? Upon what innate or learned factors does each device depend?

CHAPTER XIII

MOTOR LEARNING

LEARNING has been mentioned from time to time in our previous chapters. We have seen, in fact, that the process of learning means constant modification of responses through interaction with the environment. There is no hereditary activity which does not unfold during stimulation by the environment. Up to this point in the book, however, we have emphasized the broad outlines of human nature without considering closely *how* we learn. How and what we learn are of the utmost importance to an understanding of human nature; and we shall be concerned from this point onwards with the nature of learning and with the analysis of the more complicated human activities which depend primarily upon learning.

Learning involves (a) motivation, (b) random responses, (c) elimination of faulty responses, (d) fixation of responses which will satisfy the motive.—Whenever a human being is confronted with a new task which in time he solves successfully, his progress is subject to certain definite laws: (a) The fact that there is something to be done, the fact that there is a preliminary need or drive or restlessness, means that activity must result. (b) This activity is at first rather uncoordinated—it involves random or variable responses. (c) In the course of time many of the responses are eliminated while others of the responses are repeated more and more often Thus a man shooting at a target starts clumsily. Useless or detrimental movements of hands or of head or of trunk must be reworked or eliminated The shots fly wide of the mark. (d) In time, however, the errors decrease and the successful movements are made more and more frequently. A learning curve may now be plotted to show the mastery of the

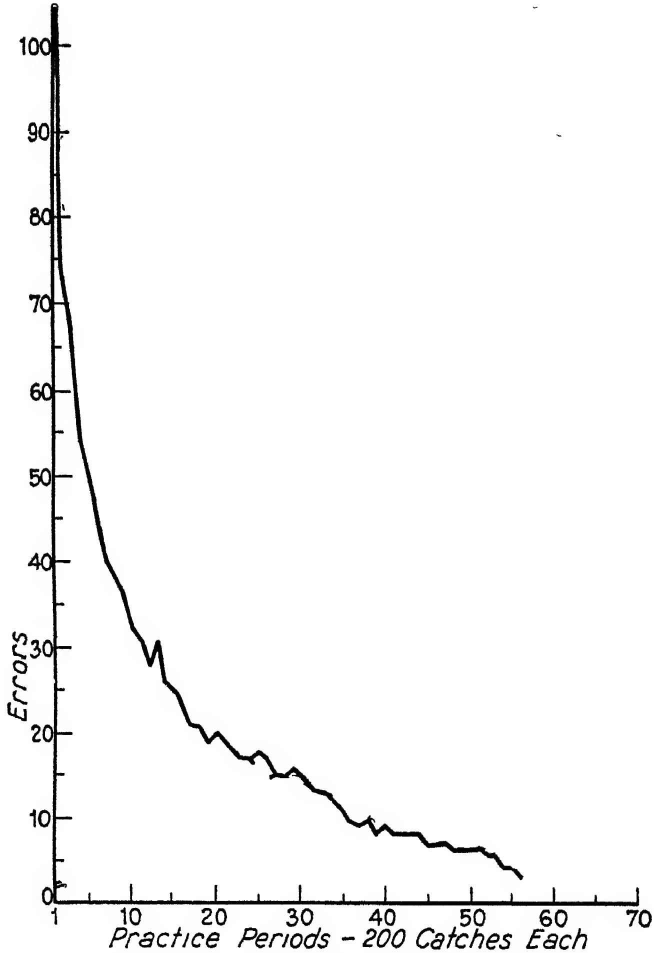


FIG 63 —Typical curve for motor learning The curve shows progress in learning to juggle two balls with one hand. The subjects in this experiment were required to keep two balls going with one hand, catching and throwing one while the other was in the air Each practice period was continued until the subject had made 200 successful catches The curve represents the average performance of thirteen subjects who practiced once a day The vertical axis shows the number of errors made (in this task an error is missing the ball) Compare the shape of this curve with Figs 69 and 74 From J Peterson, *J Exper. Psychol*, 1917, vol 2, p 195. By courtesy of the editor and the author

task Fig. 63 shows progress in ball tossing. Note how errors and useless movements are eliminated. Compare Fig. 64, which shows more directly the elimination of useless movements.

This preliminary statement of motor learning, with its graphic representation in the learning curve, will apply to a great variety of facts of learning. But learning is a little too complicated for offhand analysis. Adult human beings are the most complicated

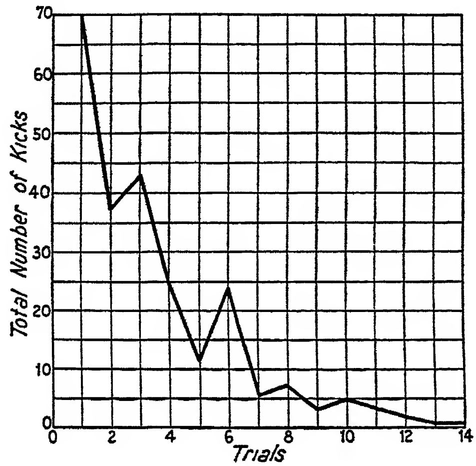


FIG. 64.—Gradual elimination of useless movements while learning a task, with more and more learning, there are fewer and fewer useless movements made. The vertical axis shows the number of times the infant kicked its legs in attempting to grasp a rattle From M. W. Curti, *Child Psychology,* Longmans, Green and Co., p. 170. By courtesy of the publishers and the author.

subjects with which science deals. In order to simplify our task, we shall do better to turn to observation of little children and of animals, exploring and experimenting to analyze the many factors which enter into the process of learning; and when this is done we shall be in a position to return to a study of the more complex facts of adult learning and thus to undertake, as best we may, a theoretical interpretation of our results The task of ball-tossing studied in Fig. 63 is novel; it is governed by incentives; it can be analyzed objectively; the results can be measured. Our problem is to find, for a simpler organism than an adult man, a task having

these same qualifications. One sort of apparatus which is exceedingly useful for such research is the maze (cf. Fig. 65) The adult, or child, or animal may be placed at the entrance, and after

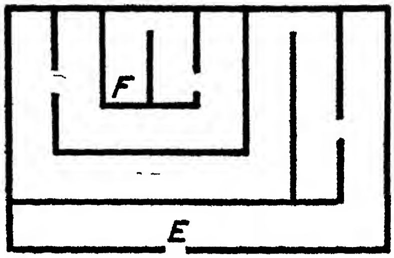


FIG. 65—A simple unstandardized maze The animal enters the maze at E and must run until it reaches the goal, food, at F With practice, the animal makes fewer entries into blind alleys The extent of his learning can be measured in terms of the elimination of errors.

finding his way to the center, receive food; as he tries this over and over again he makes fewer and fewer entries into blind alleys

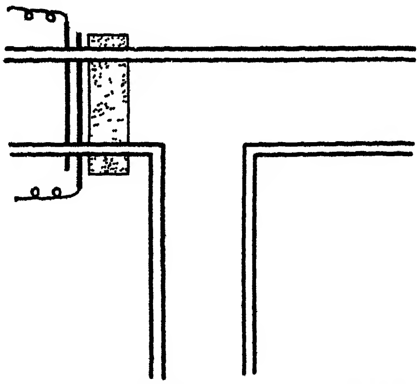


FIG. 66—"T-maze" for use with earthworms. With repeated practice, the worm learns to turn to the right when it gets to the end of the straight path If it turns to the left, it crawls over sandpaper and receives an electric shock, if it turns to the right, it escapes from the tube Modified from R M Yerkes, *J Anim. Behav*, 1912, vol 2, p 334 By courtesy of the editor.

(*culs-de-sac*) until he can run the maze perfectly Animal maze-learning can be directly compared with human maze-learning; cf. Fig. 67.

Mazes may be simple or complicated; at first sight most mazes look too complicated. Yet the maze, in some form or other, has an extraordinary range of applicability. Even as humble a creature as an earthworm when put into a T-tube (Fig. 66) can learn to turn

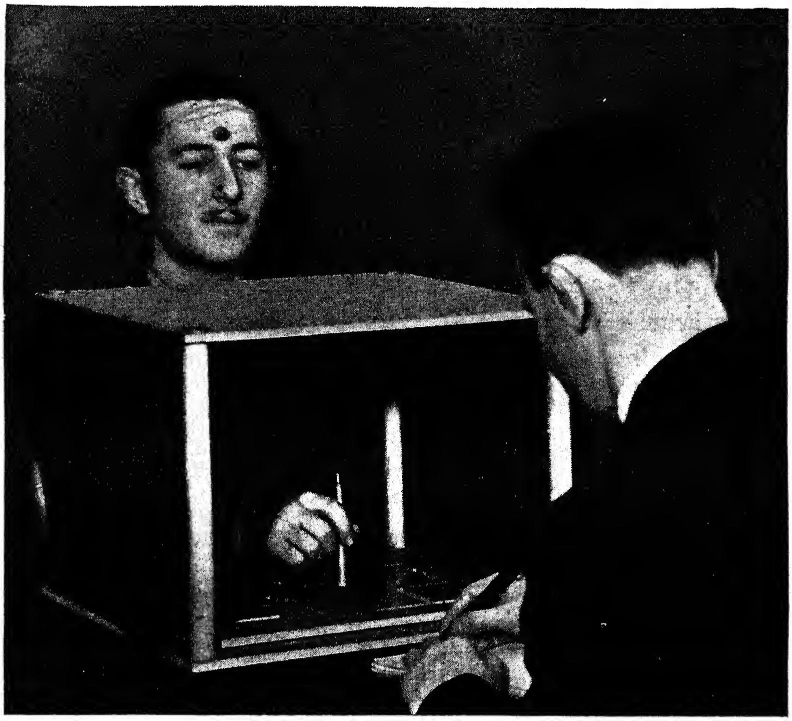


FIG. 67.—Stylus maze for use with human subjects. The maze, a series of grooves, is "run" by directing the stylus held in the hand from the "entry box," in which it is placed by the experimenter, to the goal. The experimenter records the course of the trial, the blind alleys entered, and the time required. Screening the maze from the subject prevents him from seeing the entire pattern and makes the performance somewhat more comparable to the situations that animals are put in, in the laboratory, situations of which lack of space prohibits a scaled reproduction.

to the right or the left; on one side there is earth, on the other side sandpaper and electric shock. It took the average worm fifty trials to learn this, and when it was once learned the task was "remembered" well from day to day. The worm not only turns; he turns in the right direction. In the case of vertebrates, which

have well-organized nervous systems, quite complicated mazes may be learned, and even where forgetfulness appears quickly, the material can be quickly recovered. Mazes have been used for at least a half century, and it has been conservatively estimated that 1500 learning experiments with the white rat as subject and the maze as apparatus have already been carried through. The maze experiment, because of the relative ease of standardizing it and of analyzing exactly what happens in this situation, has earned a prominent position in the study of the psychology of learning. To this should be added the fact that standard laboratory animals such as the rat take easily to mazes. Nothing is required of the animal except that he run, and the degree of his achievement in learning his way through the maze can be ascertained with reasonable exactness at any time.

By using the maze in animal experimentation, it is possible to study (1) the total time required to get to the center or to go from the center to the exit; (2) the number of errors made (an error is an entry into a blind alley or a retracing); (3) the number of cases in which an error is repeated, whether immediately after making the error for the first time or on some later occasion; (4) the nature of the changes in all these time-and-error measurements in repetitions of the experiment; (5) the total number of errors made in mastering the task

Fig. 65 is fairly typical of the older models. With simplification has come standardization The fact that the alleys are of unequal length is often a difficulty, and the fact that the angle to be turned varies at different points makes the situation different for the animal at different stages in the learning process. A standard maze has recently been built in which both lengths of blind alleys and angles of turn have been standardized, cf. Fig 68.

As we should expect from our analysis, the first thing to do is to get the animal restless enough so that he will run. Nothing causes more confusion in studies of learning than failure to control exactly the strength of the animal's motives. Usually a standard degree of hungriness is aimed at in terms of a standard interval

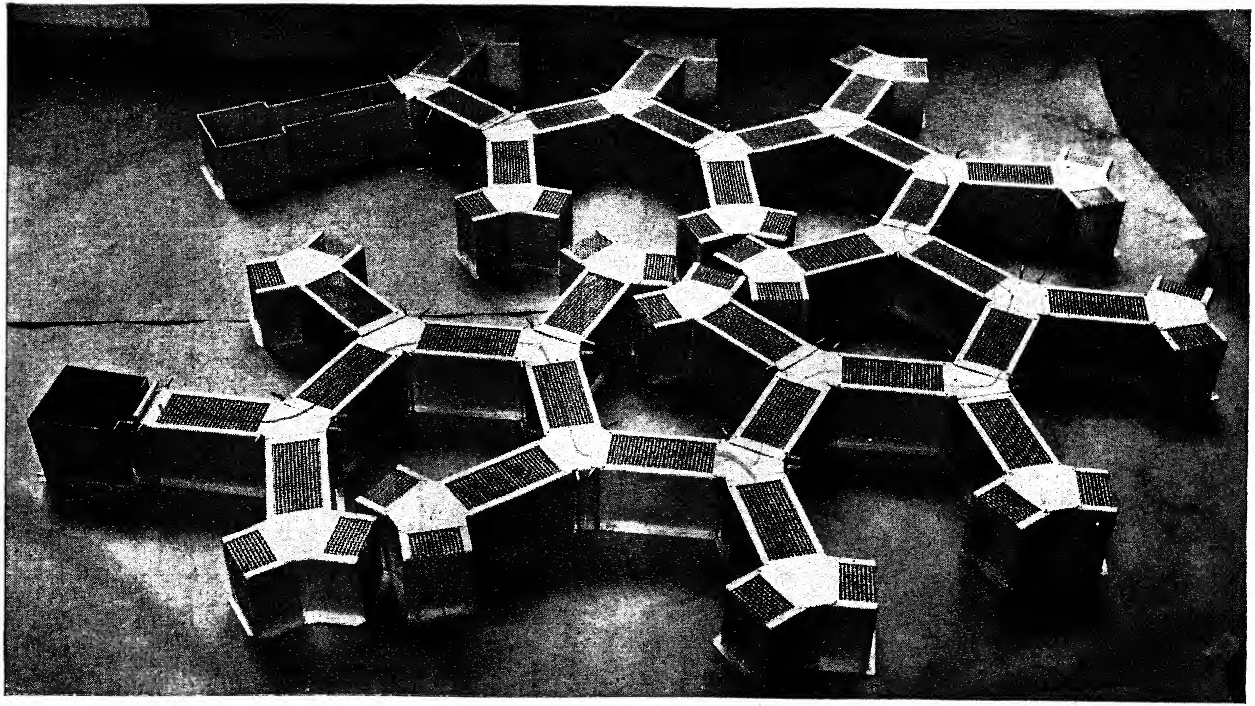


FIG. 68.—A standard animal maze, the Warner-Warden unit maze. This improved piece of apparatus opens the study of animal learning to fewer criticisms than the older mazes. The animal starts in the uncovered box at the lower left and receives a reward when he gets to the uncovered compartment at the upper left side of the figure. This shows only one of the many patterns which may be used. Notice that each of the blind alleys is the same length and is finished off at the end, so that its appearance to the rat which has to choose a runway is the same as that of the correct path. From C. J. Warden, *J. Genet. Psychol.*, 1929, vol. 36, p. 175. By courtesy of the editor and the author.

since the last meal, the animal having at this meal eaten all he wanted Results based on such a standard degree of hunger are reasonably consistent Even two different drives may give approximately the same learning curve *if each drive is very strong*; compare Fig 69.

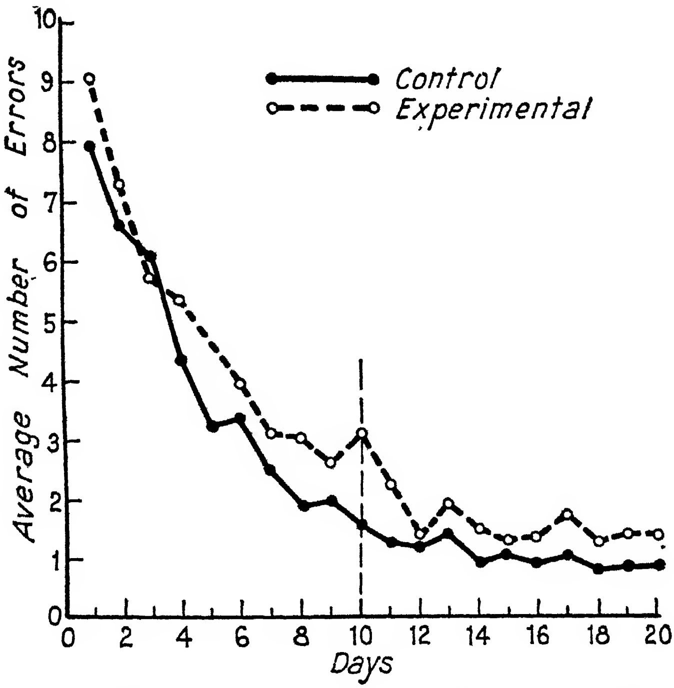


FIG 69.—The effect of changing the drive in learning This demonstrates the very slight difference made when one strong drive is substituted for another. Average daily scores for 34 experimental rats and 32 control rats which were given one trial a day in a maze The learning commenced with all animals motivated by "thirst" and rewarded with water at the goal box After nine days the experimental animals were made "hungry" but not "thirsty" and their reward was changed to food. Note how closely the two curves parallel each other both after as well as before the ninth day, even though the experimental animals had their motivation changed while the control group continued as they had begun From M H Elliott, *Univ. Calif. Publ. in Psychol.*, 1929, vol 4, p. 186 By courtesy of the editor and the author

J. E. Anderson measured the effect of a kind of incentive which might seem too extreme to work He kept two groups of white rats so hungry that they fell far below the average weight norms

for their age. One group of rats received a ration much smaller than that normally given; they were a semi-starved lot of animals. The other stunted group was given as much food as it liked, but not the variety it needed. It was supplied with large quantities of bread, but there was a vitamine deficiency. These rats, too, showed a stunting which would lead one to expect a poor showing in competition of this sort. Both groups of stunted rats clearly *surpassed* the control rats which ate the normal amount and kind of food and were hungry only to a normal degree at the time of maze-running. The result is almost certainly due to greater activity on the part of the inadequately fed animals. Other experimenters have reported cases of animals which, suffering from no special need, calmly lay down on the floor at the entrance to the maze. Learning arises when there is a motive and the possibility of satisfying it through a new way of behaving. It does not occur if there are no motives aroused.

The more directly the responses are connected with the satisfying of motives, the more promptly they are fixated.—Kuo allowed his rats to set forth in any one of four directions. They were hungry and there was food to be had, but they did not know where it was. If they took one direction, they found themselves in a compartment in which they received an electric shock. If they took a second direction, they found themselves in a compartment in which they were confined for a while—not shocked but simply detained If they took the third direction, they found themselves after a roundabout course in the presence of the food. The fourth alternative led them by a direct route to the food. Analysis of the results showed that they eliminated the electric-shock compartment first, the detention compartment second, and the long route third The more severe the punishment which results from making a mistake, the more promptly that mistake is eliminated.

It is worth while to notice that the animal is not waiting passively for something to be impressed upon him. He is building up *positive* responses to some object such as the pathway which leads

to the food, and *negative* responses to those which do not lead to it Furthermore, there is, so to speak, a degree of "positiveness" depending upon how quickly the path gets him to the food, and, similarly, degrees of "negativeness" depending upon the kind of punishment a response brings.

How the animal learns to connect up all the correct turns has been thus far a rather general question regarding the form or order of the learning process, but we may ask the question more precisely by inquiring as to the sense organs and specific cues which are important for this particular task. That the animal smells the food is beyond all reasonable doubt; but, at least on first running the maze, there can scarcely be much difference in the smell of the different alleys Scouring the maze and even moving the animal to a new maze of identically the same construction make it quite clear that the odors of his own previous path are of no consequence. He can see, but the walls and the openings, especially in the figure shown on page 233, are very similar. When rats had completely mastered a maze, they were, in one experiment, blinded and deafened, and the sense of smell was eliminated; in addition, ether was put on the feet so that variations in the roughness of the floor could not be detected; yet they could still run almost as swiftly as ever, and with few or no errors. This suggests that they had learned by the feel of the various runs and turns or, to speak more accurately, by the muscle sense (page 126), which delicately indicates twists and turns of various degrees of sharpness as well as lengths of run. Other evidence shows that in some maze-running studies, the varying sounds of the footsteps guide the normal animal fairly well Thus the muscle sense serves in some cases, sight serves in others, and hearing serves in yet a third group In fact, it is normal to learn by as many cues as one has at hand; and there is nothing mysterious about the fact that when a great many kinds of associations are formed, the removal of several sense organs still leaves the animal with some clue.

An experiment which is similar to the maze experiment in some respects makes use of a "problem box"; the animal must find

its way to the goal by operating a mechanism which will release it. Fig. 70 shows a problem box in which the animal must step on metal plates in a given order. This has been used with many animals, the complexity of performance varying roughly with

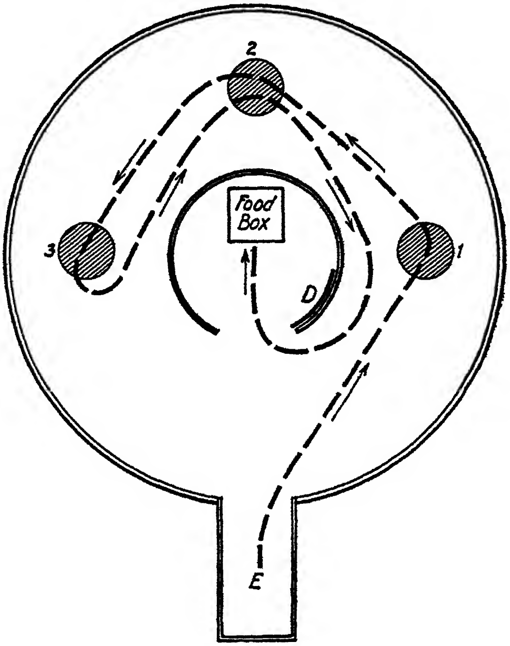


FIG. 70.—The Jenkins problem box. This box is especially suited for comparing the performance of different kinds of animals By making the box of proportions to suit the size of the animal, one can test any species that can walk or run The animal is required to step on the plates in the floor in a certain order to be admitted to the food box By making the pattern in which he must step on the plates more complicated, one can make the test more and more difficult until the point is reached when the animal can no longer learn to solve the problem This illustration shows the correct path for the fourth problem in the standard series The animal, starting at *E*, must learn to step on the plates in the order 1, 2, 3, 2, to open the door *D*, to get to the food. Cats can learn such a problem, monkeys can do far better. The plates are here shaded for emphasis, but in the original they are not especially conspicuous By courtesy of C J Warden

the intelligence of the animal. In a recent experiment a monkey learned to make twenty-two moves in the right order to earn his reward of a piece of apple. There are many other forms of

the problem box, some of which involve operating a latch to get out of a box, or to get into a box which contains food.

Curves of learning show "diminishing returns" and reach a "physiological limit."—One *quantitative* finding about the learning of simple tasks like the maze is that, when measured in terms of the elimination of errors, learning curves are of the same general form we have already seen in the case of complex skilled acts Errors in the maze are eliminated, so to speak, in large bunches in the first few trials, and in smaller and smaller number as skill is perfected. In fact, if enough measurements on enough individuals are made, the general form of such a curve can be worked out with great precision. To get a general idea of the form of the common learning curve, the reader is referred to Figs 63 and 69 on pages 228 and 234

It will be worth while to analyze more closely a well-studied case—the learning of telegraphy by human subjects—in order to investigate the character of the learning curve. In the telegraphy curves, the number of right moves made is compared from minute to minute. The task of the subject is to eliminate all moves but the appropriate one in any given case. The data may be turned "upside down," and progress may be calculated in the increasing number of right responses per unit of time, instead of the decreasing units of time per right response One important reason for the improvement is the elimination of the wrong responses. This implies that the ability to make more right responses per unit of time is just as fundamental in telegraphy as in the tasks already described. This general principle is also applicable in the case of those skilled acts in which most of the time is spent in perceiving the stimulus or in organizing the response, rather than in *executing* the response, i.e , it applies to telegraphic receiving as well as to telegraphic sending.

The same results are found in studies of typewriting, and the form of the learning curve is the same; trial and error in the perceptual and motor spheres is going on simultaneously throughout the course of learning. The first efforts at typewriting do not

necessarily involve the actual striking of wrong keys every time one has the impulse to do so. A great deal of the process of eliminating false starts is carried out internally rather than externally The first steps in a faulty movement may be carried out, and then the hand be swiftly drawn back or the movement checked before any external sign has become evident. Similarly, faulty habits of perceiving the keys, particularly in their relation

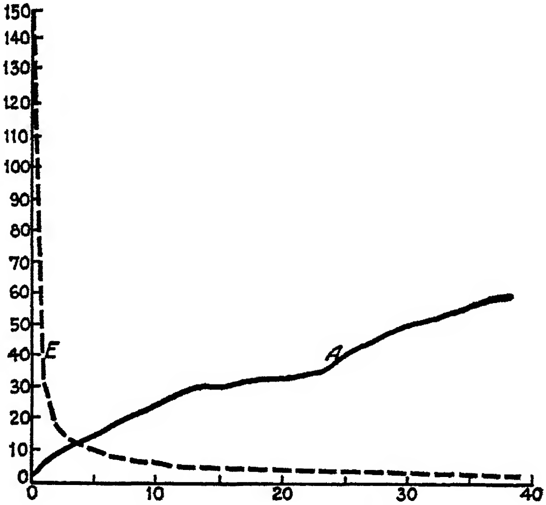


FIG. 71 —Practice curve for telegraphy. *A* is the number of letters per minute one man was able to receive *E* is the *same* performance, showing the number of seconds needed to receive five letters The horizontal axis shows weeks of practice Note the plateau, the flattening out of curve *A* between about the fourteenth and twenty-third weeks of the practice After Bryan and Harter, from J. Peterson, *J. Exper. Psychol*, 1917, vol 2, p 217 By courtesy of the editor and the author

to one another, may use up much time. Curves for progress in typing verify the steps already worked out for other tasks.

The general curve of learning exhibits the principle of "diminishing returns" which appears so widely in physical and biological sciences (page 219). Many forms of learning do show this principle. It is rather extraordinary that the curve showing the increase in the number of words typed per minute, the decrease in the number of misses in firing at a target, and a thousand

other forms of learning which have been studied, conforms in a general way to the kind of curve presented for the original study of telegraphy by Bryan and Harter (Fig 71). The curves all show a rapid gain at first, and continuous gain as time goes on, but a smaller gain per unit of time expended. There is thus a typical curve of learning conforming to the principle of gradually decreasing effects per unit of time.

A "higher unit" is a group of elements which we learn to handle as if it were only one element.—Certain irregularities appear in these curves, and we ought to find out why they occur Note the "flattening out" or "plateau" in the middle of the solid line in Fig. 71. The first stages in learning telegraphy are defined in terms of "letter habits." The individual is learning to make each letter as he identifies it in the copy. Days or even weeks may be spent in mastering the letters. During this time, faulty movements are being eliminated and rapid progress is evident The individual then ordinarily goes into a "plateau"—a period of apparent lack of progress. This may be due to decline in motivation, or distraction, or an emotional upset, or marked variability in physical condition Plateaus may also result from two or more conflicting methods of work; progress recommences when one method is established. Often the plateau results from the fact that the person has organized a given set of habits about as well as he ever can under ordinary working conditions When he starts gaining again, analysis of his records shows that he is now working in a totally different way. The telegrapher, having mastered his "letter habits," is in the *word habit* stage. Short words or syllables, or sometimes words with as many as five or six letters, are handled as wholes, not only on the perceiving side, but on the reacting side. A word is executed, so to speak, as a unit, and the fitting together of letters in words is done with almost as great facility as was the sending of individual letters a few days before Since the word is now the unit, the individual can work without the waste of time involved in the perception and response to individual letters, one by one. In this way pat-

terns of great complexity—the phrase habit, the clause habit, the sentence habit—are formed. The number of individual letters actually sent out as a unit from the brain in a given time is very great; in telegraphic receiving the operator may follow so as to transcribe one hundred and fifty clicks after the instrument, and handle a large part of this material as a unit.

In view of plateaus and other irregularities, it is evident that an absolutely smooth learning curve is a sort of ideal type which all learning curves approach more or less, but it is only an ideal, for every real curve has some irregularities Sometimes it is a mistake to average too many data before drawing a curve. For example, *every* person's curve might have plateaus, but if the plateaus came in different places they might not appear at all on a composite curve for a hundred individuals Moreover, a curve of this sort might be true for each individual if the averages of several different kinds of learning were jumbled together. There might, for example, be five different kinds of learning going on, each one serving to confuse or hide each of the rest, and no one of them corresponding at all to the curve given. In this case the curve would obscure rather than clarify our understanding of the nature of learning.

There are several possible explanations for the fact that curves of learning show diminishing returns One explanation is the simple fact that errors tend to be eliminated in the inverse order of difficulty; those eliminated first are the easiest to eliminate. Many errors are rapidly eliminated in the first practice period. More errors will be eliminated in the first five minutes than in the next five minutes; and the time required to eliminate the last error, the one hardest to eliminate, may involve many five-minute intervals. We should expect that some errors in a complex learning task would be much harder to remove than other ones and, therefore, that a curve of diminishing returns would result as more and more time is spent on eliminating a given error.

The smoother our curves the better for purposes of generalization and prediction, but they will not tell *what learning is*, nor is

it their business to do so Their business, like that of all generalizations, is to find principles which obtain when certain things *remain constant.* In the meantime there are many reasons to doubt whether generalized quantitative laws like these can describe learning except under special well-defined conditions It is far from clear that these laws apply to acts performed during emotion, or while attention wanders, or under varying incentives—in fact, in most life situations As we noted in Chapter I, the laws of science are abstractions from a confused world of nature; psychological laws are abstractions to the same degree that physical laws are, but no more so.

The conditioned response is the simplest form of motor learning.—The preceding account is of course nothing but the crudest sort of sketch of what happens in learning. We shall now have to look more closely to try to find the *simplest kind of learning.* This will help us toward understanding how the more complicated types of learning occur

As we have seen (page 33), the later stages in the evolution of the nervous system have provided a large number of specific and well-defined *reflex arcs.* These are in many ways extraordinarily adapted to the needs of the animal For example, most of them are directly connected with locomotion, the avoidance of injurious stimuli, and the maintenance of posture. Though reflexes differ greatly in many respects, such as the sharpness of their localization, the time required to arouse them, and the length of time they remain in action after the stimulus is removed, they have a number of characteristics in common. They are all touched off by some special kind of stimulus The contraction of the pupil is caused by light, but the light may vary in a good many respects without materially altering the speed of the pupillary response. The dog's scratch reflex may be elicited by pressure or irritation almost anywhere on either flank; the "extensor thrust" of his paw may be brought about by all sorts of pushes upward on the pads of the feet.

Most reflexes can be facilitated by using two or more stimuli. A small amount of acid at one point may produce a weak scratch reflex and a small amount at another point an equally weak response, but the two may act together on this "final common path" to elicit a more vigorous movement. Stimuli to different parts of the body may thus by "summation" bring out such a response; for example, the tap on the knee when one is clenching the hands is followed by a more vigorous knee jerk than when the hands hang limp. This phenomenon of *facilitation*, or mutual aid, of stimuli is especially interesting where neither of the stimuli would be able to produce *any* response at all Every reflex has a *threshold* (page 48), a magnitude of stimulation needed to bring it out. If the stimulation falls below this threshold, the response simply does not occur. Though two "zeros" do not make a "one," nevertheless two stimuli, each of which is below the threshold, may work together in such a way as to produce a response; two mild electric shocks, each too weak to arouse a response, may, when applied at different points on the flank, initiate the scratch reflex (Thus a man may remain calm until irritated by the "last straw," some trifling incident which in itself would have no effect upon his equanimity.) In the same way incoming impulses, instead of combining, may interfere, and here we have "inhibition." Paradoxically, in such cases, either one of the two stimuli may produce a response, yet the two together produce *none*.

If, while a reflex is under way, some other stimulus is vigorously presented, it usually reinforces the reflex response. Facilitation occurs even when the second stimulus bears no fixed relation to the hereditary pattern of the response When this joint stimulation has been continued for some time, the second stimulus may by itself bring about a response similar to that which first appeared in simple reflex form Bright light is flashed in the eye, causing the *pupillary reflex*, while a bell is sounded by the experimenter; after many repetitions of this, the bell alone elicits the reflex. This is a *conditioned reflex*. A dog which has been given meat powder and whose saliva has been flowing abundantly as he

eats, hears a tuning fork as this food is given The tuning fork reinforces the salivary flow and in time will cause it, *even if no meat powder is present.* This kind of research is associated with I. P. Pavlov and his pupils in Russia

Turning to another field, we find that learning by conditioning may be illustrated by experiments with the "galvanic skin reflex" An infant a few months old was stimulated by a faint electric light held in front of his eyes; his response was in every case "positive," i.e, he smiled, gurgled, or held out his hands. With the electric light another stimulus was now given—a sudden noise The response to the noise was "negative," and included change in body resistance to the current (page 107). In time the light *alone* would produce this internal change. The response formerly appropriate to a noise could now be elicited by a visual impression. The noise is an "unconditioned" stimulus to certain sorts of bodily reaction; the light, after the process of conditioning has occurred, is a "conditioned" stimulus We shall use the terms "conditioned reflex," "conditioned response," and "conditioned reaction" interchangeably.

In most experiments on conditioning, the "substitute" stimulus is presented either *together with* or *just before* the original stimulus In some cases, the substitute stimulus is presented for a short time and then discontinued so that there is a "blank" period between the substitute and the original stimulus. Human beings and higher animals can form connections even over a time period of this sort. Not only may a conditioned response be built up in the dog when the substitute stimulus is given and then discontinued a half hour before feeding, but the dog may become conditioned to the time interval itself, so that the flow of saliva begins half an hour after the substitute stimulus, even when the animal is asleep. In many cases, the substitute stimulus continues to act for the whole half hour and is still acting when the original stimulus is presented

To summarize the principle by means of a diagram, suppose that an infant is stimulated at the same time by noise and light; the arrows show the formation of a conditioned response:

Stage 1. Noise — Withdrawing

Light — Reaching

Stage 2.

Withdrawing

Light

A stimulus may be connected with a new response only if the latter is a dominant response.—Will an infant in such cases be negatively conditioned to the *light*, or will he become positively conditioned to the *noise*, or *both?* Experiment shows that as a rule both associations are not formed. One stimulus is dominant over the other. After the experiment just described, *either* the light *or* the noise will call out withdrawing, but the reaching response will appear with *neither* stimulus. Which stimulus is to be dominant depends upon the strength as well as upon the quality of the stimulation. A case has been reported in which a dog given meat powder at the same time that the paw received a slight electric shock could be conditioned in either direction by varying the strength of the stimuli; a *great deal* of meat powder and a mild shock meant that the shock came to be a substitute stimulus and made the dog's mouth water without making him draw back his paw, while a *small* amount of meat powder and a relatively strong shock meant that in the next trial the meat would itself make him draw back the paw.

Dominance is also the clue to the elimination of conditioned responses.—When a child is conditioned to fear a rabbit by being bitten or by some other mild accident, the conditioned response of fear to the rabbit may be eliminated by bringing the rabbit to the door during lunch time. The rabbit must at first be kept far enough away so that the positive response to the food dominates the situation and the rabbit becomes a part of the whole positive situation.

Stage 1. Bite Fear
Sight of rabbit → Fear

Stage 2. Sight of rabbit → Fear / Joy — Uncertain or alternating responses
Food . Joy

Stage 3 Sight of rabbit → Joy

In this way one conditioned response is dropped and another built up. In one experiment the rabbit was brought so close that the child actually played with it, but when the child's fingers were nibbled again, a long reconditioning process had to be repeated.

Conditioned responses often die out if the original stimulus is discontinued. If a dog is fed when hearing a tuning fork and forms a conditioned salivary response to the tone, this lasts only a short time after the artificial connection between tuning fork and food is broken. Let the tuning fork be given without food a few times, and the saliva no longer flows This is called experimental *extinction.* Since the dog is, of course, being stimulated by all sorts of other things in the room besides the tuning fork, there is good reason to believe that this experimental extinction is like the elimination of the conditioned response just described. Any conditioned response will tend to drop out if other stimuli are cutting in and dominating it by reconditioning. Conditioned responses do not stick for life except where they are of overpowering strength.

Suggestion and imitation obey the law of the conditioned response.—"Suggestion," the blind following of a verbal command, is based largely upon conditioned responses to familiar words Since tendencies to action are conditioned to specific words, there is often no distinction in little children between "automatic"

and "voluntary" responses to words. What we call the suggestibility of little children is often nothing more than the fact that response patterns have been built up which are touched off by words uttered by adults The child is suggestible simply because in early life there is nothing much to interfere with the execution of the simple acts named by older people This tendency is increased by the fact that adults are apt to hold a child's attention; what they say is apt to have the right of way in competition with other stimuli In fact, if the adult does not have the right of way, we comment on the child's "absent-mindedness" or absorption in his own affairs, or may even call him stubborn or "negativistic."

The same explanation of suggestibility applies throughout life. Under certain conditions people remain like children in their tendency to respond uncritically and automatically to verbal stimuli. The technique of advertising and of propaganda makes use of such facts as these. On the positive side, the suggestion is constantly repeated; on the negative side, all interfering suggestions which might bring up interfering habits of thought or action are avoided

The psychology of *imitation* is likewise rather simple, if we define imitation as the doing of something because one observes another doing it. This also fits the formula for conditioning. Let any given condition in the body produce a movement—for example, the raising of the arm. Since we *see* the arm as it rises, we have a conditioned response in which, since all these events are occurring at once, the sight of the arm as it rises becomes a substitute stimulus for the original "cause" which made us raise the arm Thus a child who has once started making some random movement may make it a hundred times. Almost any random activity may be repeated over and over. This is the "circular reflex." The sight of the movement is the stimulus for the movement. If, now, someone else raises the arm, the situation is similar to that in which the child raised his own arm, so that the child repeats the movement. One experimenter found that all the children tested between ten and twelve months of age raised their arms when she did and, similarly, carried out other imitative

movements like shaking the head. In the same way small children often repeat what is said to them if the sound is something they have already uttered in their own babblings. From this the paradox appears that one can imitate only what one has already done One cannot imitate *someone else* unless one has already *imitated oneself*. When the adult imitates a complicated act carried out by

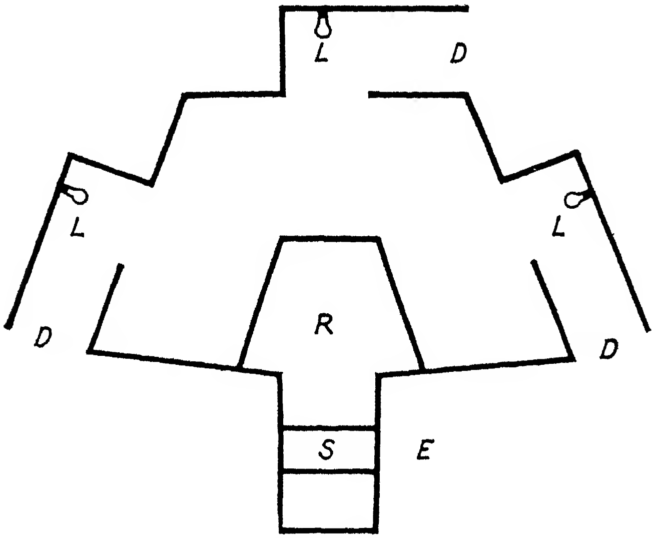


FIG. 72.—Ground plan of the delayed reaction apparatus The animal is placed in the release box (*R*) The light (*L*) in front of one of the sliding doors (*D*) is then turned on momentarily After an interval the release box is raised by the experimenter (at *E*), who is screened from the animal by pasteboard and the switchboard (*S*). When the animal goes to the light box previously illuminated, the sliding door is opened so that the incentive (usually food) may be obtained. From W. S Hunter, *Behavior Monog.*, 1913, vol 2, p. 23 By courtesy of the editor

another it is only because he has already learned how to make the act or the component parts of the act which can now be put together. Heifetz can imitate Kreisler if he wishes, but you and I cannot imitate Kreisler Most adult imitation is the fitting together of habits which have been previously learned.

The delayed reaction is a special form of conditioned response.—If a child or animal has learned that an object is important because of what goes with it—has learned, for example,

that a light appearing above a box means that food is contained in the box—an interesting problem arises: If the signal is removed, how long will the individual continue to behave as if it were there? Suppose we have three boxes all built alike with lamps so placed that any one may be illuminated while the other two remain dark (Fig. 72). The child or animal learns to fixate the light. He is, however, restrained from going to the contents of the box until after the light has been put out. Will he now be able to go at once to the box which had the light, or will he lose his way? Some of the lower mammals which have been studied by this method "forgot" as soon as they turned their heads away As long as they kept their noses pointing toward the position of the light, the interval could be of many seconds' duration between the extinguishing of the light and the liberation of the animal from his confinement; the animal simply followed his nose, but had no other mechanism by which to adjust himself. If the animal had been turned, he tried to find the right way, but the location had been lost. With some animals, however, it is possible to turn them about every which way and immediately on release from the cage have them go to the right box Nearly all twelve-months-old children can make for the right one of three boxes many minutes after the clue is removed, though playing with other toys in the meantime. The apes excel at this sort of problem, remembering for hours just where a cherished object has been hidden, although engaged in many other activities in the meantime. In a sense this might be used as an "intelligence test" for animals and even for human beings. This "delayed reaction" experiment suggests that conditioning is a direct avenue to more complex problems.

Note also the difficult tasks which may be studied by the method shown in Fig. 73. The subject in this experiment must keep in mind a task which may be made more complicated as fast as the experimenter desires. Such an experiment shows how our capacity to keep in mind a complicated task and to follow a set of directions to which we have listened illustrates the basic principle of the

delayed reaction. Even such a complicated thing as following directions may therefore be shown to have a great deal in common with the conditioned response.

The conditioned response is a clue to the psychology of complex motor habits.—Let us see what use we can make of the conditioned response as a clue to *learning in general.* If a

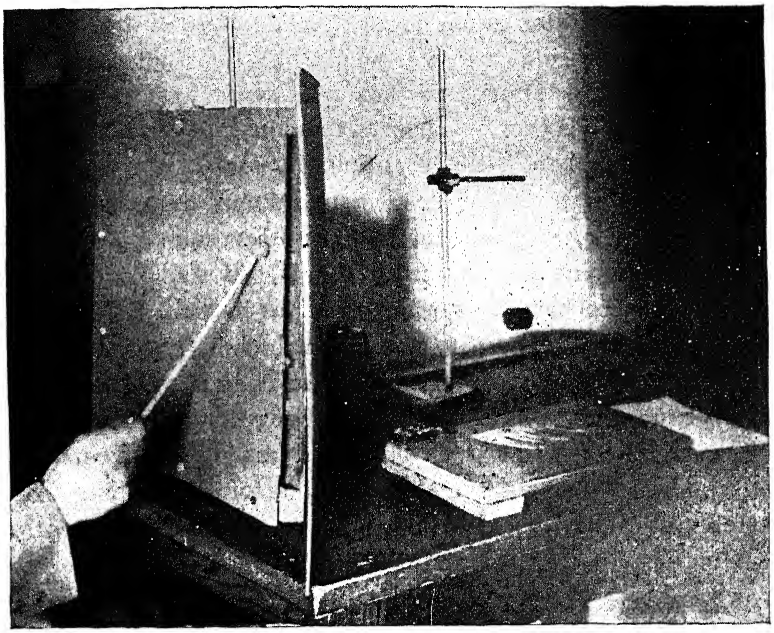
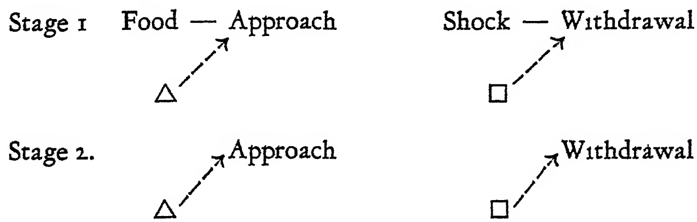


FIG. 73.—Apparatus to test "set." By means of this apparatus we can find how complicated a pattern a man can keep in mind. Ten lights arranged in a circle are mounted in front of the subject who is being tested. The experimenter is hidden from view and flashes the lights on and off in different orders. The person tested indicates the order in which the lights were flashed on. The complexity of the pattern can be increased by the experimenter until the subject is no longer able to follow correctly. From R. Gundlach, D. A. Rothschild, and P. T. Young, *J. Exper. Psychol.,* 1927, vol. 10, p. 250. By courtesy of the editor and the authors.

hungry animal confronts two runways, A and B, over one of which there is a triangle and over the other a square, he may try either one. But at the end of one is food; at the end of the other, shock. Whenever the experimenter reverses the position of

food and shock, he reverses triangle and square. In time the animal learns to avoid the square if it has always meant shock, and to choose the triangle if it has always meant food This may be presented in terms of the conditioned response:



The learning of a maze involves a series of choices so that if each turn in the maze is learned by discrimination, and if discrimination is just a matter of the conditioned response, then the conditioned response is a clue to maze learning

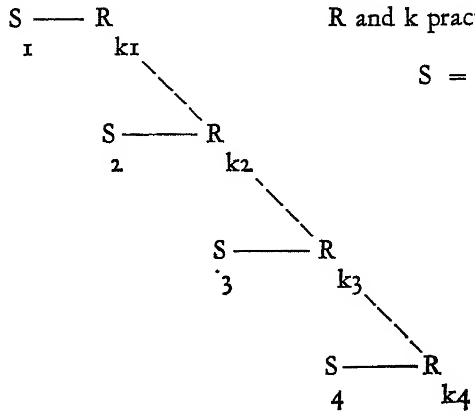
As to the way in which the various turns in the maze become connected up so that the animal can run swiftly from one end to the other, it is possible to state the whole thing in conditioned response terms The animal runs the maze chiefly through the use of his muscle sense (cf page 126). Each turn in the maze involves not only muscular responses but muscular sensations. The animal, while learning, sees a succession of new turns to be made and, as he makes each one, gets muscular sensations which coincide with what he sees next. Since these muscular sensations coincide approximately with the sight of new alleys while the animal is learning the maze, the muscle sensations act as substitute stimuli for the sight of the alleys. When the maze is learned, he can run the maze even if blind, because each pattern of muscle sensation sets going the next appropriate muscular response. Cf. the diagram on page 252. The assumptions here are: (1) that the animal makes at random, i.e., by trial and error, all sorts of movements, of which a few are appropriate; (2) that the appropriate movements are positively conditioned and the others are negatively conditioned. Thus the conditioned response is a clue to the formation of *any* habit involving a series of movements.

In learning:

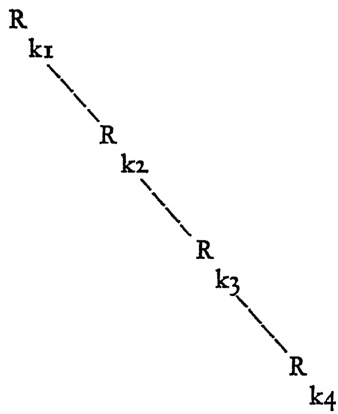
R = muscular responses
k = muscular sensations

R and k practically simultaneous

S = sight of a turn in the maze resulting in a muscular response



After learning:



The original conditioning is to the food in the maze; hence, if the conditioning theory is correct the *last* turn in the maze should be learned *first;* in fact, there is, in general, a tendency to eliminate errors near the food box more quickly than those near the beginning of the course The animal seems to learn "backwards" from the last successful step In a recent study in which four

standard tasks of exactly equal difficulty were presented to the rat, he usually got the last step right before he got the next to the last, and so on. The theory of conditioning also holds good for other simple habits; it applies to the connecting of a number of rapid movements, as in buttoning up one's vest or tying one's shoes, granting, of course, that tactual cues assist the muscular ones.

This view is all right as far as it goes. But it does not go far enough to explain all learning. Breaking everything down into conditioned reflexes, we are apt to chop the learning process into tiny fragments and to forget that the animal does really learn the maze *as a whole.* If, for example, the animal runs through the maze till he has learned it to a certain degree of excellence, and then the same maze must be traversed by *swimming* instead of by *running*, he goes without a halt (Fig. 74). Although the actual movements of swimming are very different from those of running, experience with one gives practically perfect transfer to the other. We have trained more than just the specific movements of running; the whole animal, probably including head and trunk movements, has been trained So, too, if he has learned at first through *swimming* he can be transferred to a maze which has to be *run* and his progression continues normally. Furthermore, rats suffering from injuries to the cerebellum (which is important in muscular coordination) may be completely unable to carry out *any* of the muscular responses which they had learned in the maze, yet they can get through the maze without an error. As Lashley says, they can even "roll" through it. Individual nerve connections are certainly being formed, but probably in most cases the animal *as a whole* is learning the task *as a whole.* It is not merely a case of each muscle performing its own little task in the total; the organism functions as a whole.

That simple trial and error does, in the long run, eliminate errors and select advantageous reactions seems clear. But many exceptions to such a principle are equally important. Errors are not automatically and inevitably eliminated; a great deal depends on the condition of the animal. In some situations, the very fact

that an error has been made baffles, upsets, or disturbs the animal or man, and he may blindly repeat the faulty reaction for a long

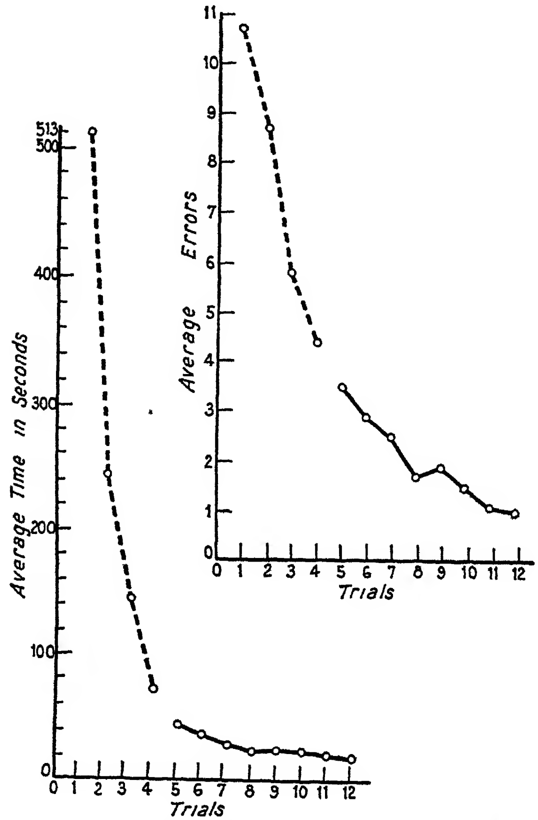


FIG. 74 —The learning curve of a group of 19 rats that first *ran* four trials in a maze and then *swam* the next eight, using the same maze but with a changed flooring. The upper curve shows the continuous decrease in number of errors made, and the lower curve shows the corresponding steady decrease in time, in spite of the vast difference in the *specific bits of behavior* which the task called for after the change From D A. MacFarlane, *Univ. Calif. Publ in Psychol*, 1929, vol. 4, p. 292 By courtesy of the editor and the author

time. The fact that a false start has been made seems to make a particular erroneous response *more* likely rather than *less* likely to occur in the next trial In human beings a punishment (electric shock) may sometimes help in eliminating errors, but in some

cases it actually hinders elimination of the error, or even fixates it. The indiscriminate punishment of small children for misconduct often upsets them and causes bewildered repetition of the offense.

A general tendency toward persistent "stereotyped" modes of searching is also found in maze experiments This stereotyped reaction seems to be exaggerated by gross failure in the solution of the problem, but this type of response must not be regarded as necessarily stupid. There is a certain method in the animal's behavior in many cases. Its behavior is not really "random" It works in a more or less consistent way, attacking one particular part of its problem over and over again and remaining relatively indifferent to other parts. This is much like the human tendency to get a definite hypothesis or plan of attack in mind before or during a task

The concept of conditioning is of great importance, but its place in the *total pattern of a complicated response* has to be kept in mind In view of the immense importance of the concept of the conditioned response, it is well to make it do all the work it can do, especially in the explanation of the simpler habits. The conditioned response is a most useful *clue to*, but not, strictly speaking, an *explanation of* all learning, since we must always be alert to the *way in which separate reflexes are combined or reorganized.*

One of the most important kinds of learning is the complete reorganization of behavior, not piecemeal, but all at once.—Some of the simpler facts of learning and association have been described Yet some of the more complex learning processes—such as learning to play chess or to interpret poetry or painting—seem to awaken sudden and dramatic acts of *insight*, and the clue to these more complicated processes must be examined. They will help to show how learning, thinking, and perception are all bound together by certain common principles

Since sudden transition from one response to another is a normal fact of behavior, it is natural that perception undergoes sudden shifts of the same sort. The change is often not piecemeal but

all at once, as will be illustrated by Fig. 75. The cubes may be counted to give different results, depending upon the way they are seen. The staircase in Fig. 60 (page 214) seemed to change from a position approaching the reader to one retreating from him. It is characteristic of visual fields to change as well as to *reconstitute* themselves completely. Since this is so, it is to be expected that in any learning process the pattern of the stimulus

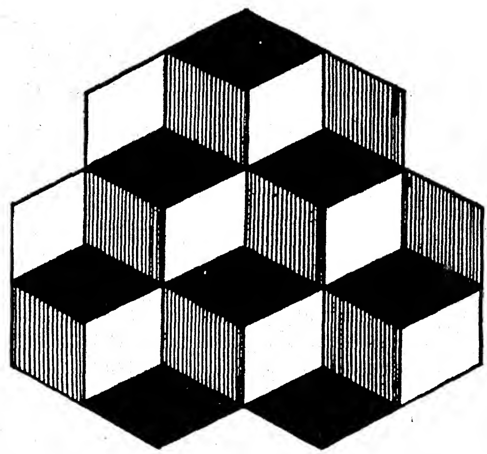


FIG. 75.—There are either six cubes, or seven, depending on the way one looks at them.

will appear to change frequently though the external environment remains unchanged. The very fact of varied response makes this inevitable. This kind of sudden shift, both in what we do and in what we observe, is very important for a theory of learning.

During a series of investigations in the Canary Islands, the German psychologist Köhler investigated the ways in which objects are perceived by chimpanzees. He noted a large number of cases in which their random attempts to solve a problem, such as getting food out of a puzzle box, were abruptly terminated by a new insight into the nature of the task. An animal which had been floundering unsuccessfully for hours suddenly saw that a stick lying nearby could be used to reach the food. In another case, a blanket which was lying in the cage was suddenly seen

as a possible tool for the same purpose A third observation is of special interest; the ape, having played aimlessly with two sticks for a long time, making unsuccessful efforts with each one, began to see that when one was stuck into the end of the other, they would make a stick long enough to reach the food. The basic fact of *insight* seems not to differ from those sudden shifts in the perceptual field which are involved in the simple reversible figure shown above. In fact, it does not differ from those instances in which one tries to find in the Sunday newspaper the three men and four animals concealed in the drawing of a landscape. The artist designs his lines in such a way that only under special conditions will the faces and figures pop out so as to be separated from the background. Such cases may, if we like, be called cases of "sudden insight." It is hardly worth while to argue about the best term to use. The fact that apes, dogs, and many lower animals have sudden shifts in their perceptual fields is no more surprising than that they have sudden shifts in their muscular responses In fact, many of the muscular responses depend on the perceptual side of the animal's or man's responses. To give immediate and fresh experience to illustrate what is meant by insight or reorganization, Figs 76a, 76b, and 76c are shown. For most persons, the first is "easy," the second "harder," the last "very hard."

There has been much discussion as to whether the fact of insight necessitates abandonment of the trial-and-error theory of learning. Sudden shifts in the perceptual field may sometimes be useful, sometimes an obstacle to success. In cases where one has already had experience with the situation in hand and has nevertheless begun a new attack in a wrong way, it is likely that a sudden shift will take the form of a return to a previous effective perceptual pattern. In other words, we see the situation the way we saw it at the time of some previous successful handling of it This will mean in the long run that the shift from blind activity is apt to be in the direction of more effective activity, since every time there is a shift there is the likelihood that we shall recognize the task as one which we solved some time before. Of course, the

FIG. 76.—Figures illustrating "insight" or "reorganization" in the perceptual field. The separate elements in each of the figures have to be integrated. "Insight" is shown in grasping the pattern, putting the parts together to make a meaningful whole. From R. F. Street, *A Gestalt Completion Test,* Bureau of Publications, Teachers College, Columbia University, pages 41, 55, and 65. By courtesy of the publishers and the author.

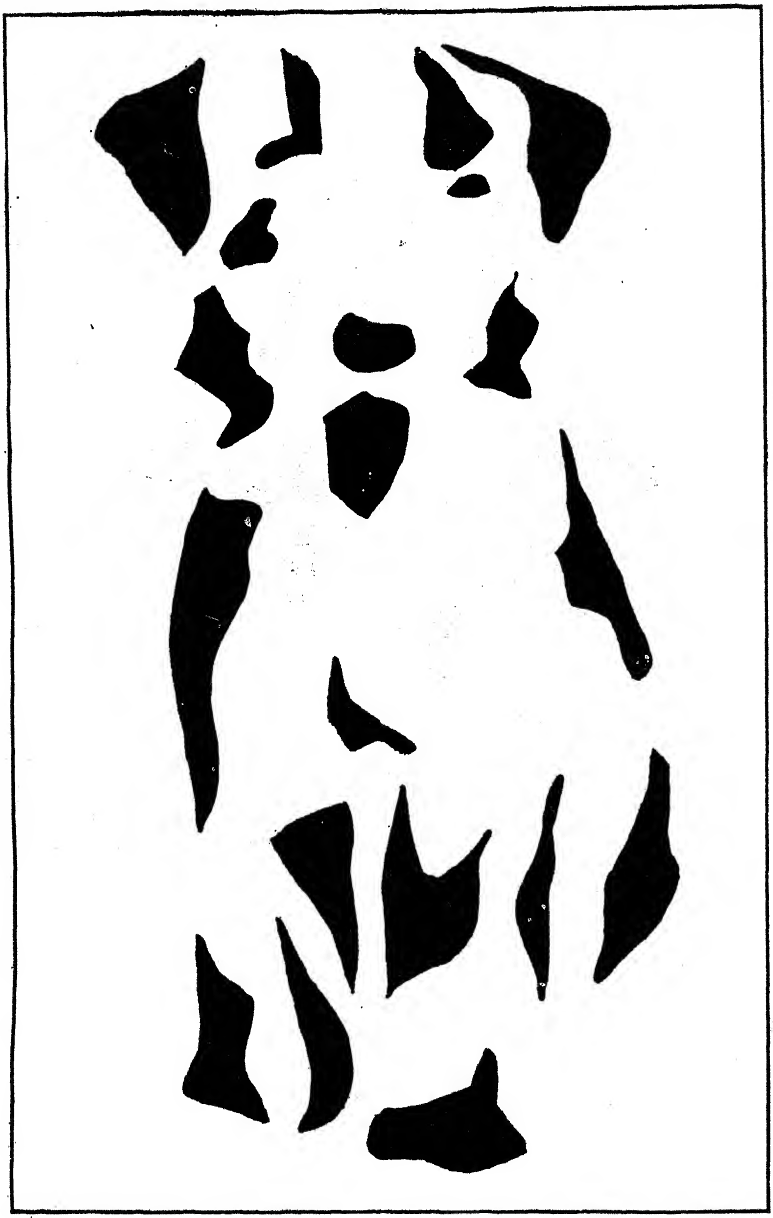


FIG. 76a.

Fig. 76b.

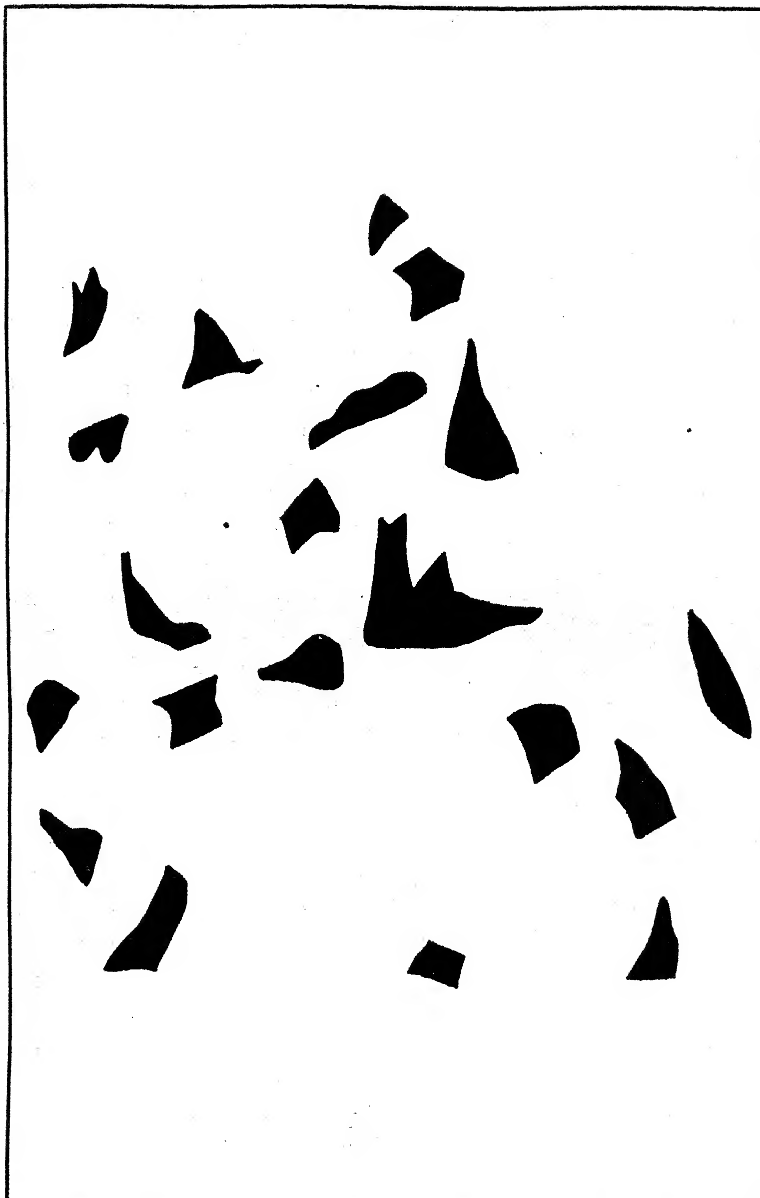
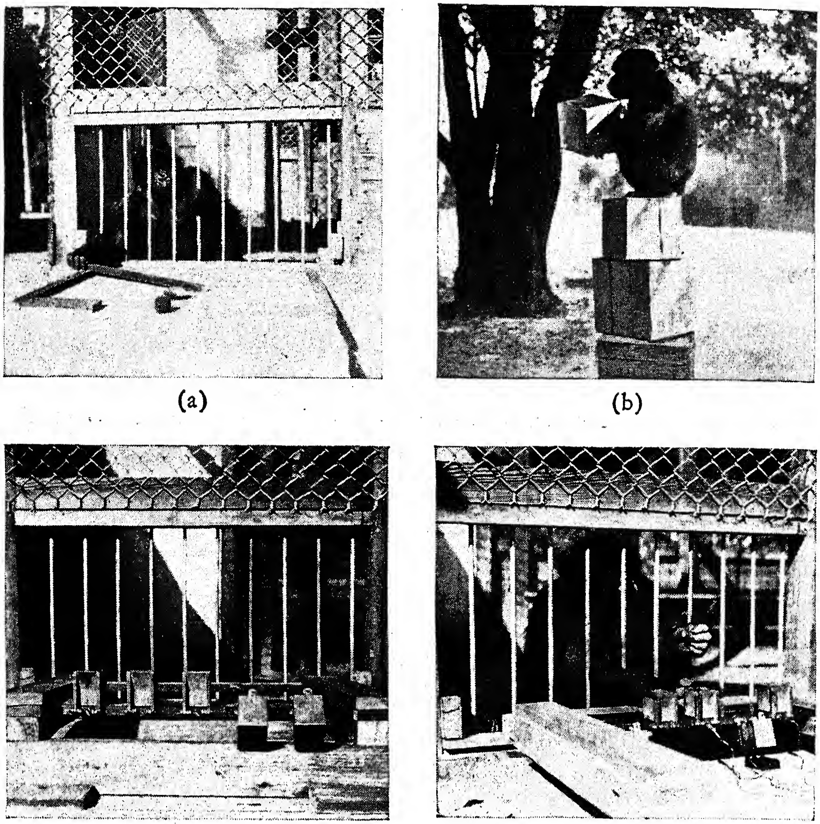


FIG. 76c.

insight response may, as it actually occurs, be nothing more than a response based on *previous conditioning*, and this would explain the overt muscular response, but not the *dynamics* of the perceptual shift. As we have already noted, the dynamics of shift in response seem closely related to the *varying threshold* (page 210). These shifts are not random; they "close" an incomplete pattern and put an end to a strain.

The shift may be useful even when the animal has not dealt with such a situation before. This naturally suggests comparison with what we call "creative thinking" in human beings. Köhler and those who have worked along lines similar to his have usually concluded that this kind of perception goes entirely beyond the ordinary trial-and-error explanation; that is, they assume that such insight shifts in perceptual pattern are adjusted to the needs of the situation more adequately than can be explained in terms of past experience. In the nature of the case, this is difficult to prove without a detailed life history of each animal or man for whom such results are claimed. In some cases the insight can be shown to be largely dependent on past experience, and that past experience was really full of trial and error; cf. Fig 77. In other words, the perceptual shift was actually the result of past learning by trial and error.

Yet radically *new* insights seem to occur in the higher animals as well as in man; there is nothing supernatural about such a principle and no reason to reject it if it can be well established. Obvious illustrations will occur to the reader, for example, in working originals in geometry or in solving mechanical puzzles; there seem, then, to be genuine insights which are not simple carry-overs from previous situations Instead, they are responses to the entire geometrical or mechanical setting In other words, one has learned how to work in spatial terms Similarly, a golfer may confront a situation very different from any which he has ever encountered on a particular course, yet the good player will get out of the difficulty more quickly than the beginner. Here we are dealing with a complexity of conditioned responses all acting at once. Yet an adaptive insight of this sort is not just a



(a) (b) (c) (d)

FIG. 77.—Some apparatus to test the mental capacity of apes. In (a) a stick is used as a tool. In (b) boxes must be piled to make a tower from which food can be reached. In (c) and (d) apparatus is shown which permits the experimenter to hide food in one enclosed box while the animal looks on; the animal is later released and the experimenter notes whether it can remember which container was used (a wrong choice results in the animal's receiving an electric shock).

Roughly speaking, (a) and (b) show the study of insight, while (c) and (d) represent the study of learning and memory. In contrast to the insight of chimpanzees, this gorilla showed a long series of fumbling "partial insights." For example, she at first swept the stick toward herself even when the food was on the other side of the stick; and in box building she had to receive "lessons" from the experimenter. Such objective studies of partial insight help to unravel the problem of what "reorganization" is. Compare page 256. The gorilla was also far inferior to the chimpanzee in memory experiments involving (c) and (d).

From R. M. Yerkes, *Genet. Psychol. Monog.,* 1927, vol. 2, nos. 1 and 2, pages 50, 120, and 544. By courtesy of the editor and the author and of the Yale Laboratories of Comparative Psychobiology.

transfer from a particular situation; it is the simultaneous use of a whole *system* of appropriate habits picked up in the past The *act of organization* is what is new.

In one study of learning to play chess the organization constituted a large part of the basis of insight. As the experimenter said, "To a great extent the material organized itself." Insight in the sense of sudden reorganization in the perceptual field is a part of the problem of learning But it is also a part of the problem of thinking, and we shall return to it in that connection.

Learning to use words illustrates all the main principles of motor learning.—A child's learning to talk will serve as a summary and review of principles, for it brings out almost every principle that has been considered under the general topic of modification of behavior.

The child's cries and wails and fragments of babbling which are made in the first few weeks or months are modified through the circumstance that some of them bring good results These can be observed to be slowly fixated, usually in the form of separate syllables. The thirsty child discovers that *wa* brings water, or *ma* brings its mother's smile or attention, if a "baby talk" word is accepted by adults to mean something, it is all right as long as it works. The *elements* thus picked up piecemeal are *combined* in word units exactly as already discussed in the case of telegraphy and typewriting The growth of vocabulary, words which are meaningfully used, is especially rapid in the second half of the second year.

There is parallel development of active and passive language. While the child has been acquiring "active language," that is, *using words* to get results, he has also been acquiring "passive language," that is, *learning the meaning of words he hears.* Often the words are used by adults while the object is in the child's sight or just before it appears. The principle of conditioning explains a good part of the adjustment of the body in preparation for the coming thing. The hungry child's wails can be stopped when he has learned that the word "bottle" is really followed

by his bottle. Moreover, the interweaving of associations, as we have already seen, involves changes in patterns of perception. In fact, the entire bodily response represents an interwoven pattern of perceptual and motor functions.

Understanding of words is not the only function exercised by the hearing of words. There is a tendency for children to repeat words they hear. Little children echo back to you what you say to them, often quite ignorant of your meaning This is the circular reflex (cf. page 247). In this way vast numbers of new syllables are picked up at a time when the brain is just advanced enough to make this association easy, but not so advanced as to make the individual reflect about the fact that he is repeating. In general, this description fits the second and third years of life, and it is in this period that the first tremendous gain in active language appears. Of course, a great many of these automatically repeated sounds are made in situations where attention is directed to something of immediate interest which is named by the adult. Here, then, the principle of responding to the word as one would respond to the thing itself can function well, and many meanings are acquired in conjunction with the rapidly accumulating vocabulary of monosyllables or other short words.

Active language is partly based on passive language Not all of the child's active language arises directly from what he hears; many words arise from modified babbling which undergoes changes until it produces satisfactory social results (page 263) Even deaf children stumble upon combinations of throat and tongue movements which bring results, and these tend to be learned though the words are never heard. In general, active and passive language habits grow together. On the one hand, the random production of sounds is replaced by short and clear pronunciation of words which bring quick and definite rewards An adult quickly and easily understands what the child wants. On the other hand, the sounds which the child makes approximate more or less those which he hears, and it is evident that social approval and quickness of favorable response go with correct copying of the adult words. Baby talk may persist for years, the

child using a jargon of his own at home because it gets results, but resorting to the "standard English" of his environment when necessary. The active and passive language habits become associated to the point where teachers forget that these ever constituted two distinct sets of habits.

The later stages in language learning are conspicuously rich in the organization of higher units, both perceptual and motor. Language is the most complicated skill which most persons acquire; it is to be doubted whether even the playing of a large pipe organ or the conducting of a symphony orchestra is more complicated than the skillful handling of our words in conversation Finally, the tendency to the repatterning of verbal material into new forms, the reorganization of the whole structure of a sentence which one reads or struggles to compose, is identical with the repatterning we have already considered. This serves as a clue to the organized structure of an intricate verbal pattern as it imposes itself full-blown on the mind of a creative writer like Carlyle or Nietzsche

SUMMARY

Motor learning depends upon: (a) a drive; (b) restlessness; (c) the elimination of responses which do not satisfy the drive; (d) the fixation of those responses which do satisfy it The learning curve shows diminishing returns from practice, but it is irregular because of the formation of higher units and other changes in the subject's way of working. A conditioned response is the fixation of a dominant response to a stimulus which originally could not evoke it. Suggestion and imitation as well as the delayed response are special forms of conditioning. No matter how complicated the process of learning, motor habits may be regarded as made up in large part of a series of conditioned responses appropriately connected. An organized whole is ultimately built up, and the general form of response may be repeated even when specific reactions which have been learned can no

longer occur Sudden insight in the process of learning is due to reorganization in the perceptual field and reorganization of motor responses The learning of language illustrates all the laws of motor learning.

REFERENCES

Garrett, H E, *Great Experiments in Psychology*, 1930, Chapter IV.
Hunter, W S, *Human Behavior*, 1928
Lashley, K S., *Brain Mechanisms and Intelligence*, 1929.
Pillsbury, W. B, *Essentials of Psychology* (3rd ed), 1930, Chapter V
Thorndike, E. L., *The Fundamentals of Learning*, 1932.
Watson, J. B, *Psychology from the Standpoint of a Behaviorist* (3rd ed), 1929, Chapters VII, VIII.
Wheeler, R. H., *The Science of Psychology*, 1929

PROBLEMS

1. If you have ever trained either an animal or a very young child analyze the ways in which "conditioning" took place in the process of the training.
2. Most of the present discussion of learning has been concerned with skilled acts State any examples you can think of in the realm of emotions or of personality traits where the same principles might apply, and show how you think they would apply
3. Can you think of any conditioned responses that appear to involve only one part of the body? Can your observations be reconciled with the view that the whole organism, rather than simply a reflex, has been modified?
4. Do you think of any reason why the salivary reflex should be considered an especially good one to choose for experimental purposes?
5. From your own experience in mastering any complicated task, illustrate each of the following·
   (a) Rapid initial improvement.
   (b) Gradual slowing in the rate of improvement (reason for this?)
   (c) Plateaus.
   (d) Rise from a plateau (Discuss possible reasons for this rise: changed incentive, loss of interfering factors, higher units, etc)
6. What explanations can be offered for the fact that in some learning situations animals surpass men, and children surpass adults?

CHAPTER XIV

IMAGERY AND ASSOCIATION

IT TAKES a certain length of time (usually from about .005 to about .1 second) to arouse a sense organ; time is also spent in exciting the nerve fibers which lead to the brain. The brain connections themselves consume time; the outgoing nerves, their junction points with the muscles, and the muscles themselves, take time. This matter of "latency" or tendency of a bodily tissue to take time before making its normal response is of great significance in relation to learning The facts of latency are, indeed, a beginning for the consideration of the nature of imagery For there is a normal *after-discharge* after a sense organ or a nerve cell is excited; compare the quantitative evidence in Fig 78. Just as it takes the retina a few one-thousandths of a second to respond to a bright light, so it takes the retinal elements some time to *cease responding* after the light has been removed. If a tachistoscope is used, permitting the instantaneous shutting off of a source of light which has been fixated, the object will still be clearly "seen" after the stimulus is gone. The fading is gradual This "lag" effect can be greatly prolonged by the use of brighter stimuli or very prolonged stimulation. The longest periods of true "seeing" occurring in ordinary normal subjects from brief stimulation seem to be of a few seconds' duration, but a fair number of adults and a large number of children continue to see for a much longer time, indeed, in some cases for a matter of hours. To these cases we shall return a little later.

Residues of sense impressions are called "after-images" and "memory images."—Ordinarily the thing ceases to be seen, but something remains afterwards which is *like* the thing seen, something which has most of the characteristics of the seen object.

In this group belong the images of the sun which linger long after one ceases to look at it. These are "after-images" The moment at which to designate the beginning of the after-image is an arbitrary one The fading-out process is going on in the retina and in the brain at the same time, and the distinction between seeing and imaging involves a question of degree.

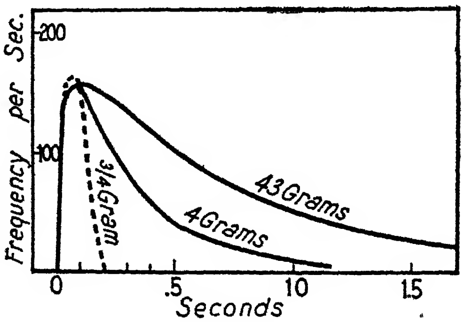


FIG 78—After-discharge The length of time during which nerve activity continues after stimulation ceases These curves were obtained from a preparation of cutaneous nerve stimulated by a needle point with different amounts of pressure This chart shows that the *duration* of the after-discharge depends on the *original intensity* of the stimulus Note that the *immediate* response of the nerve is not, in this case, directly dependent on the intensity of the stimulus, but that the intensity does affect the subsequent activity of the nerve. From E D. Adrian, *The Basis of Sensation,* W W. Norton & Co, p 95 By courtesy of the publisher and the author

After the first after-image, which because it is like the original sensation is called a *positive* after-image, has faded away, it is often followed by a *negative* after-image, an image having the same shape and size as the original object but a different color, usually the complementary color of the one first seen. The images of the yellow sun which begin to appear a few seconds after shutting the eyes are characteristically blue or purple. Curious sequences of different colors will appear under special conditions when the eye is stimulated for a long time with one hue. All these effects are largely due to the chemical properties of the retina. Even the negative after-image is much more than an "optical image."

In time, the negative after-image fades; and yet the stimulating object still seems somehow to be there; there remains a picture or image of the sun. We "remember" how it looked though we no longer actually "see" it. This "memory image" is at first vivid; it gives way, in turn, to an ordinary image or picture in the mind's eye, which is no more vivid or realistic than any ordinary mental picture one calls up.

This long series of optical phenomena certainly depends on both retina and brain; but it is also practically certain that the first stages depend more upon the retina than the last stages do. It is well to remember that the retina is largely made up of nervous tissue and is in a true functional sense a part of the brain. Most visual imagery of the ordinary type involved in memory seems to depend on brain activities somehow resembling those which occurred when we first saw the object.

Over twenty subjects—including several advanced students aware of the tricks and devices to which they were apt to be exposed—were asked to sit down before a screen in a dark room and vividly imagine various familiar objects such as tomato, banana, jackknife They were asked to "project" images on the screen, that is, to imagine them as they would look if projected on the screen. Without any warning to the subjects, the experimenter threw a faint image on the screen The subjects thought that these projected images were the results of their own imaginations, even though the properties of the object shown—its location, position, color, etc—were sometimes deliberately determined by the experimenter in a way contrary to the way in which the subject had been told to "image" the objects. The later introspections showed that the subjects had seen not what they set out to imagine and project, but what had actually been thrown on the screen.

The conclusion was that not one of these subjects was really able to tell consistently when he was seeing and when he was imagining. Such an elaborate experiment might be considered unnecessary in view of the ease with which a good conjurer can

make his subjects "see" things which are "not there" Many well-known conjuring tricks are done in full light, with the subjects staring directly at the point at which the "hallucinated" object is seen.

Images, when vivid, become hallucinations.—When images have their origin in the brain and not in something disturbing the sense organs, they show how artificial the distinction may become between what we call "subjective" and what we call "objective," as far as concerns the actual nature of any given experience. Macbeth, contemplating the murder of Duncan, sees before him a bloody dagger, tries repeatedly to clutch it, but finds that it is not there. To Macbeth, as to a delirious patient, what is an image and what is a sensation cannot be discovered by analyzing the thing itself. Macbeth cannot even tell whether the dagger is there or not until he tests the sense of sight by the testimony of the sense of touch. Visual experience itself is about the same whether really seeing or whether undergoing hallucination. The image may sometimes seem exactly like a sensation. It is only by comparing it with other sensations that we call it "illusory"

Usually we apply the term "illusion" only in cases where there is activity of the sense organs; an illusion is a *misinterpretation of a sensory stimulus*, as discussed on pages 185 ff An hallucination, however, is an experience based on *imagery*, in which there is no known excitement of the sense organs.

The sense of hearing yields some of the imagery phenomena described in the case of seeing, but not all of them. The middle and inner ear continue to function for only an exceedingly short time after the action of air waves upon the eardrum. There is no true auditory after-image. On the other hand, a voice or a tone may be heard after it has physically come to an end; this corresponds in fact to the *first memory image* of vision, which, as we noted, follows upon the after-image There is, then, presumptive evidence that in this case, too, the brain activity has its own "lag"; it continues to act for a little while after the cause of the action has disappeared. The first vivid image of hearing fades out until only

the ordinary memory image is left But the sound may after a time suddenly come back with convincing realism. It is hard to tell how much of this is due entirely to the brain and how much may be traced to muscular activities. In most cases the running of tunes in the head is tied up with a tendency to hum, to pound with the fingers, etc, so that perhaps the auditory images come back by virtue of their relation to these muscular acts. Sometimes, however, sounds do seem to come "sauntering back" into the mind without any definite muscular accompaniment. There is no general reason why memory images should not under certain conditions become specially vivid; a trained musician may be able to hear a whole orchestra mentally. Many composers depend largely on such "inner hearing," and insist that they would be entirely unable to work if they could not do so; such a case will be described on page 361.

Francis Galton sent out a letter fifty years ago to inquire of hundreds of people as to their mental pictures or "pictures in the mind's eye." He was astonished to find that they ranged all the way from those who had no visual imagery whatever—those who never experienced mental pictures at all and regarded the question as sheer nonsense—to the other extreme at which persons reported that full-fledged visual hallucinations, not clearly distinguishable from actual seeing, were a part of their normal everyday existence. Galton made up a rough quantitative scale to grade the vividness of visual images, and later he and others devised similar scales for the quantitative grading of visual and auditory, tactual and olfactory—in fact, all kinds of images. In most people visual imagery was found to be much better developed than any other sort, while auditory images came second. Most people had some degree of endowment in several imagery fields Very few, if any, lacked all imagery, although learning or abstract thinking seemed to weaken it Most men whose training was in abstract modes of thinking were weaker in imagery than average people of less specialized training.

It must be added, however, that the more precise methods of grading the intensities of images had to be abandoned as a result

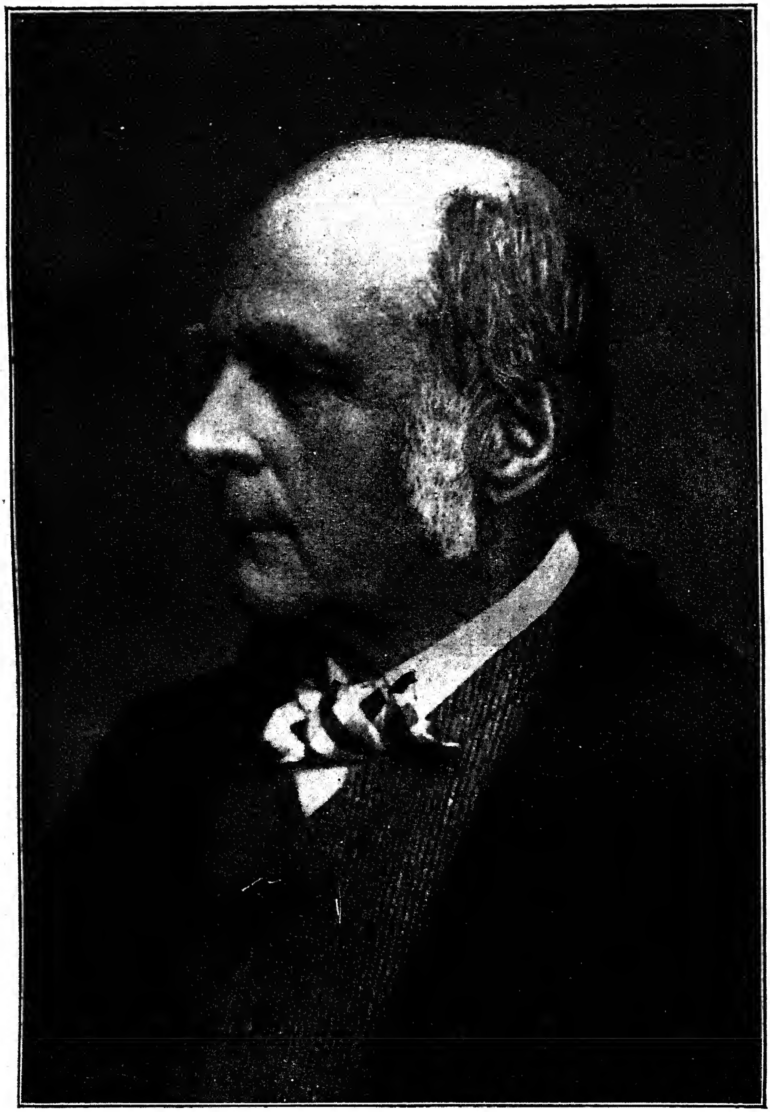


FIG. 79.—Francis Galton. Photograph by courtesy of James McKeen Cattell.

of the uncertainties which well-trained introspective psychologists presented when reporting their experiences. It is doubtful whether the degree of vividness of a visual image can be correctly graded even by as coarse an instrument as a "five-point scale," where 5 represents an hallucination and 1 represents the absence of imagery. For example, it is doubtful whether a value of 3 given to an image on one occasion means the same as a 3 given on some other occasion even by the same subject.

In the face of this fact, objective devices for the study of imagery have been developed. One device, the letter-square, has aided

P	L	R
J	F	X
T	M	V

greatly in the task. Have the subject fixate the square for one minute. The eyes should then be shut and a vivid picture of the square called up in the mind's eye. Most subjects are sure they can do this. If they are told to repeat the letters of the square, they repeat them in the order in which they were learned, that is, left to right and the lines from top to bottom. If, however, the experimenter asks that the subject start with the upper right-hand corner and read down vertically or diagonally, or that he begin with the lower right-hand corner and read to the left, the subject is completely lost He must go back to where he started and painfully get the letters back one at a time, until he can piece together what is demanded of him It is quite obvious from such experiments that he does not really "see" the square mentally as well as he supposed.

An even more objective device for checking the reports of imagery is to require definite paper-and-pencil outlining of visual images projected upon a screen. Even the subjects who assert that they are frequently fully hallucinated are unable to mark the contours of such images as distinctly as they can mark the contours of objective things which are actually seen.

Some adults and many children do, nevertheless, continue for minutes, or even hours, to see, vividly and in great detail, objects at which they have previously looked. These experiences are in many ways like full-fledged hallucinations, except that the individual knows the object is "not really there." To these realistic images the term "eidetic" is given. There are many types of eidetic images. Some are plastic, rich, intimately interwoven with the emotional life of the individual; and sometimes they are subject to voluntary control. Many creative artists (e g., Blake and Goethe) have lived among such visions In other "eidetic" individuals the images are unchangeable and unrelated to personal wishes or interests They are like a "foreign body" in the mind. They haunt or confuse the possessor; one boy saw scraps of hallucinatory images on every page he tried to read, and they interfered with his study. These individual differences are related to the glandular make-up Eidetic images are probably richer in early childhood than later. Galton's principle about the thinning out of imagery as a result of abstract thought is related also to eidetic images, since formal education seems in general to destroy this kind of vivid experience in most persons

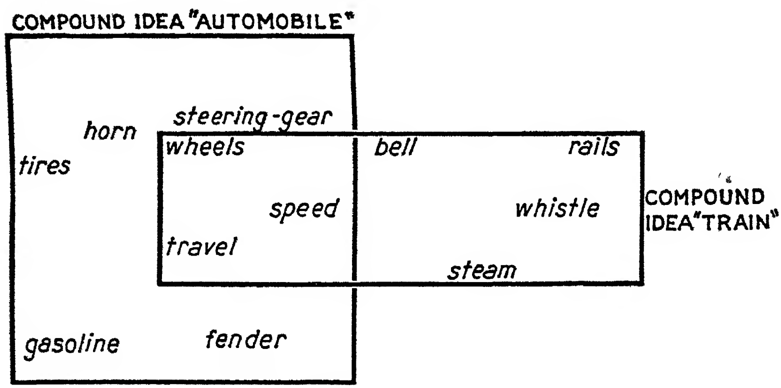
There is a rather common tendency to tie images to sensations in some other field of experience, as when a person thinks of one tone in connection with each recognizable color, or forms a visual image of a color as characteristic of a given song Many persons think quite naturally of their acquaintances as having bright yellow or dark-brown voices Observant novelists, knowing how widespread such habits are, have written of "shrill colors," "dark-brown tastes," and the like. That this is commoner than we usually recognize is suggested by the fact that in a recent study most subjects judged dark-colored cubes to be heavier than light-colored cubes which were of just the same weight. Muscular sensations are vividly connected by familiar usages with these "heavy" colors. It would be interesting to try a similar experiment involving the temperature senses, since artists have taught us to refer to "warm" and "cool" colors. This connecting of images with sense impressions from another field is called "synæsthesia."

ASSOCIATION

Free association illustrates the "laws of association": (1) contiguity in time; (2) contiguity in space; (3) similarity; (4) contrast.—In everyday experience images *follow one another* according to certain definite *laws*; these are the laws of *association.* According to an old tradition, we associate things if they have been connected in (1) time or (2) space, or if they are related by (3) resemblance or (4) contrast. The word "cloud" might therefore lead to the associations, (1) "evening," (2) "sky," (3) "fog," (4) "sunshine." How does the evidence stand in respect to these principles? Certainly the principles, as in the illustrations just given, have a common-sense utility It has been shown, however, that all these laws are really examples of one law. Contiguity in space or time helps us in forming associations only if the things are actually *experienced together*. At the moment of reading this book there is an infinite series of events happening near and far from the reader The fact that they are occurring at the same time will not associate them with the act of reading this page unless he experiences them together and forms his own connection. In a sense, this is a way of saying that things contiguous in space or time may be noticed and reacted to in such a way that they really become two aspects of the same thing. Association by similarity illustrates this same law if two things have common elements. If "automobile" makes one think of "train," it is because some elements in the idea of automobile are also elements in the idea of train. Each element is tied to the remaining elements of the idea by contiguity in experience. For example, in the pattern *horn, tires, gasoline, steering gear, wheels, speed, travel, fender,* some elements—e.g., *wheels, speed, travel*—have also been connected with *bell, rails, whistle, steam,* which also appeared in a different pattern (compare the figure on page 276). Finally, association by contrast involves both association by similarity and association by contiguity. Boys and girls are alike in being children,

and they are mentioned together hundreds of times a year. Day and night are alike in that they are parts of the 24-hour cycle, and it is difficult to think of one without thinking of the transition to the other

The "secondary" laws of association include (a) recency, (b) frequency, (c) vividness.—These laws, which are probably true and useful as far as they go, are supplemented by "secondary laws of association," relating to the relative potency of the factors of *recency*, *frequency* and *vividness*. These secondary laws do not act as substitutes for the primary laws mentioned above Rather, they act to determine the relative potency of particular experiences. "House," for example, is connected by contiguity with "yard," "street," "town," etc. But whether the word "house" will make us think of "yard," "street" or "town" will depend on the relative recency, frequency and vividness of each of these associations.



If we have just been talking of a white house the architect of which is a friend of ours, the word "house" is much more likely to give rise to the association "white" or "architect" than to a word like "wood" which has no special interest and has not recently been connected with the term "house"

The experimental study of the relative importance of the secondary laws of association—recency, frequency and vividness—has been carried through by means of the following technique. A series

of words, each of which was followed by a two-place number, was shown to a large group of subjects:

SOAP	12
GORGEOUS	35
RACCOON	21
GIRAFFE	70
AMIABLE	97
SKY	18
SOAP	12
RAMBLE	39
CART	15
RACCOON	21
SOAP	12
BICYCLE	42

The subjects formed associations so that a later presentation of each word would enable them to recall the corresponding number. To test the importance of frequency, the number of times that a word and number appeared together was varied through a wide range; the importance of recency as a factor in association was estimated by comparing the late exposures with the early ones; and vividness was studied by comparing associations in which colored stimuli were used, or numbers in large type, with those in which small black numbers appeared.

By such a method, recency was found to be much more important than frequency, and frequency in turn more important than vividness Other experimenters working with other combinations of stimuli have obtained results which differ from these, as is to be expected from the fact that the degree of vividness produced by various experimental methods will differ greatly, and that the potency of recency and frequency will depend on the novelty and interestingness of the stimuli, their likelihood of producing interference with one another, and the ease with which they are read.

When Francis Galton first used the "association test," he wrote words on slips of paper, put them under a book, and on a later

occasion suddenly exposed them one at a time, waiting until two ideas had risen in his mind, and then recording these in whatever form came easiest The classical laws of association about which English psychologists had written seemed to Galton to be capable of direct experimental testing

The German laboratory psychologists of the period proceeded to standardize laboratory conditions of presenting the words and recording the responses, and the response time was measured. They made up lists of words which were either pronounced to the subject at given intervals (say, one every five seconds), or shown on a tachistoscope or screen. The subject was to respond with "the first word that occurred to him." The answer, however, had to be *one word* simply because descriptive phrases regarding visual images or other associations could not be reduced to precise experimental form. Cf. page 105.

The relation of stimulus to response was then analyzed from many points of view. The association might be "outer," that is, it might reflect merely a superficial resemblance or superficial point of contact between the two things designated; or "inner," that is, it might show a grasp of an intrinsic similarity in meanings. An early classification based on this fundamental distinction included as "outer" associations the association by "contiguity" (hand—wrist; night—moon), and "speech habits" (good—bye; Mary—lamb); and as "inner" such groups as: synonyms (baby—infant), supra-ordinates (house—building), etc.

Strictly speaking, the associations are not *free* at all. The subject, for example, who gives a two-syllable response to a two-syllable word, a one-syllable response to a one-syllable word, etc., or the subject who replies to every noun with another noun and to every verb with another verb, can scarcely be said to display that "freedom"—that tendency to escape from all mental steering processes—which we sometimes like to think of Experimenters with the free association test have sometimes been alarmed to find that subjects take very literally the directions to "say anything that occurs to" them. One gets from one perfectly normal subject such examples as the following: house—ouse, book—ook, Thomas

—omas; from another subject one gets: go—fog, rhyme—century, sad—octopus; or, finally, such curiosities as these: right—put, summer—why not, boat—yes. In all three of these cases the experimenter is apt to be exasperated. He is sure that the subject's associations are not really free. To be sure, they are not. But they

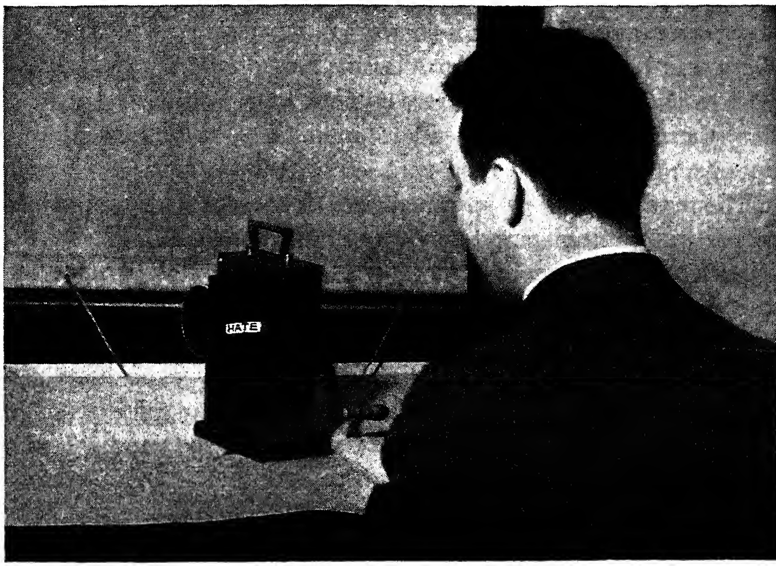


FIG. 80.—Automatic exposure device, invented by Lippmann. In experiments in learning and association, it is often useful to be able to present a list of words, or other stimulus materials, in a standard way and at a fixed rate. Lists of stimuli can be affixed to the surface of a drum, the rim of which can be seen at the left of the screen containing the slit where the words appear. After the clockwork has been wound at the beginning of the experiment, the drum turns suddenly through several degrees by means of a gear system, and a stimulus appears before the subject. The time between exposures and the length of each exposure can be controlled.

are as free as in the ordinary experiment in which the subject gives himself the definite task of getting one response for each stimulus, and of saying something which does not sound too absurd and which he thinks the experimenter will accept.

Among college students it is not altogether rare to find that the whole idea of the association test is foreign and unintelligible. One student required in each case five or six seconds to think of

any word whatever. His habit, on hearing words, was to think of what they *meant*, and nothing else His mind started off on a track of analysis in which visual patterns of some complexity probably appeared, and it was only with the greatest pressure and after dozens of practice words that he began to grasp the task as one which did not have to be infinitely laborious He was a somewhat above-average student and a somewhat above-average athlete, and there was no more reason to classify him dogmatically as queer than to classify as queer those who react with familiar stereotypes like the following: rich—poor; mountain—valley; window—door; apple—pear.

The tendencies to pass from particular to general, from general to particular, from part to whole, from whole to part, etc, are found in abundance in most normal subjects. The relative frequency of the different kinds of association has been intensively investigated. Differences between men and women, between adults and children, between educated and uneducated persons have been reported. In general, the speech-habit type of response tends to crowd out the others at higher levels of education; and the relatively superficial mechanized responses, like table—chair, black—white, finger—thumb, tend to supersede those reflecting specific experiences in the past or those involving the mere use of synonym or definition.

Another way of using the association test is through a "frequency table," which shows the relative frequency of each response to each stimulus. If, for example, the word "dog" is given to a college class, over half the students usually respond "cat" If the word "light" is given, about three-quarters usually respond "dark." To the stimulus-word "table," the word "wood" is a fairly common response; about one student in ten gives this The response "statistical" is not often given to the stimulus "table," yet it is appropriate enough. A word like "mountain" may not be given by anyone, yet if a student has recently visited Table Mountain, the normality of the association is evident. The tendency to give a large number of words *which no one else gives* is sometimes a sign of mental abnormality. The association test has,

in fact, considerable value in exploring mental abnormalities, particularly in their early stages. It is helpful in studies of mental conflict where a word which to most of us is neutral or colorless—a word like "house," "head," or "city"—produces a violent emotional upset. The tracing back of such responses to their origins in the emotional histories of individuals often discloses conflicts which need to be cleared up (cf. page 107).

The association test throws much light on the nature of association. Although the association test does not reveal any associations which are *absolutely* free, the general distinction between "free" and "controlled" association is important.

Relatively free association occurs when the eyes are shut and the individual lies half-asleep in the darkness. Various patterns of association follow one another in a "random" sequence, a sequence more or less similar to the patterns of flaming-up and dying-down in embers. Previous patterns, active during the preceding waking hours, are important in determining the lines of least resistance. The degree of activity in various parts of the brain is affected by shifting blood supply Free association tends to be chaotic and dream-like—clowns, circuses, elephants, tusks, pianos, Chopin In fact, a simple reverie or dream might perhaps be based entirely on shifting tensions or drifts of energy from one brain pattern to another.

Controlled association illustrates the principle of mental "set."—Free association is much less important than that type of association which is governed by a *"set,"* or steering process. Most of our association is really controlled by our habits and interests. As we saw in the study of motives (page 63), excitation of the vital organs and the corresponding excitation of certain parts of the nervous system is certain to make some connections much easier to form than others. Controlled association would follow a pattern more or less predictable through knowledge of brain patterns which are specially active We saw that the conditioned response is more quickly formed in the hungry dog than in the dog which is not hungry because the salivary centers are more

active (cf. discussion of dominance, page 245). Similarly, activity A is more likely to excite activity B than activity C if B corresponds to a biologically energetic disposition. Any line of thought, no matter how rambling, would tend to be headed back constantly toward the thing that is exciting the brain at the moment The hungry man trying to finish a task so that he may go to lunch is constantly interrupted by the thought of food, even though such interruptions delay his getting to the food When near a goal, children and adults often make more errors than in the earlier stages of learning; the nearness of the goal interferes with control of the necessary skilled acts. This usually happens if motivation is intense enough. Ordinarily the control which is present is sufficient to guide the process of association in more or less appropriate channels for an hour or two Even under the relatively comfortable conditions which are usually adopted for ordinary study, the question of drive keeps coming into the problem, a few hours being found the limit for smooth concentrated application to most tasks which have been experimentally investigated. The point is not that the student's brain is incapable of longer work, but simply that the control activities which drive him onward to master his calculus or his English history are unable to compete with the increasing tensions which come from the study situation and from distractions. It is probably for this very reason that one can shift to a second task and start in with complete freshness The novelty of the second task may arouse such interest as to make all signs of fatigue disappear.

That "free" association is usually not free, but controlled by motives or emotions, has been stressed particularly by students of daydreaming or fantasy. This tendency to steer one's thinking processes directly by one's needs or wants is called *autistic thinking* —thinking which is its own reward. Autistic and realistic thinking differ not at all in respect to their ultimate dependence upon motive, for both are equally motivated They are distinguished in terms of the immediacy or remoteness and the complexity of the control. If one studies in order to learn, learns in order to take a civil service examination, takes the civil service exami-

nation in order to earn a salary, and earns a salary in order to keep the wolf from the door, he may find that to keep his attention on his books is difficult. Here, if one succeeds, we speak of controlled association. The same individual might have no difficulty in controlling the wish-fulfilling fantasies in which success has already been achieved In both cases the thinking is controlled, but in the case of holding the attention on the bookkeeping or the arithmetical problem, internal steering factors are much more complicated. This seems to show itself directly in the muscular tension involved. It is as if the individual had to keep the "tonus" of the muscles to a certain point in order to make the brain associations form themselves at all.

Often the motive is nothing more than the desire to follow directions and do well in a standard experimental test Such controlled association is studied by presenting to the subject a series of tasks in which he must find elements which fit into some *definite scheme.* He must, for example, find the opposite of each word given in the following list On the left, we have what are called easy opposites, on the right, hard opposites.

Easy		Hard	
good	______________	amiable	______________
far	______________	anxious	______________
rich	______________	admire	______________
low	______________	merry	______________
heavy	______________	serenity	______________

The normal association time for the easy opposites is about half a second to a second, and for the hard opposites a good deal more. To be sure, the easy opposites will consume considerable time if a subject is suddenly confronted with a word and expected to give its opposite, but when the list is given under experimental conditions, the subject settles down to his task; and while he is giving the opposite of one stimulus word, he is already reading and forming the associative connections for the next opposite. This process of *overlapping* by which one process is in the perceptual stage while a preceding process is already finding motor expression is identical with the overlapping process in

skilled acts where the eyes keep ahead of the hands. Controlled association may, in such cases, be extraordinarily swift and accurate.

The kinds of control, however, vary greatly in the speed shown. Thus, the opposites test with familiar adjectives can be performed very much more rapidly than the part-whole test with familiar nouns (hand—arm, or finger—hand), or the genus-species test (tree—pine, or animal—dog). Such evidence as we have suggests that the speed of association depends partly on the frequency with which a certain kind of control has been used and partly upon the element of choice or selection which enters into a task To pass from the names of cities to the countries in which they are located —as Marseilles—France, Naples—Italy, Hamburg—Germany—is much easier than to pass from the countries to their cities—as France—Marseilles. This is perhaps partly due to the fact that in identifying places, addressing envelopes, and so on, we have passed from the city to the country a great many more times than we have passed in the reverse direction. But it is also probably due to the sheer fact that an embarrassment of riches confronts us Italy may set going weak associative trends toward Milan, Venice, Florence, Rome, Naples, none of them powerful enough to crowd out the rest. In the case of the association Naples—Italy, no interferences of this sort occur

It is therefore very apparent that mental set, or control, exercises an overwhelming influence upon the ordinary processes of association. In the next three chapters we shall see that it is of overwhelming importance also in relation to memory, thought, and imagination.

SUMMARY

The immediate after-effects of stimulation give rise to after-images. Memory images come later. Images are connected with one another by virtue of past experience just as motor acts are connected The sequence of events in the world of images illustrates the primary laws of contiguity in time, contiguity in space,

similarity, and contrast, and the secondary laws of recency, frequency, and vividness All these laws operate in free association. Controlled association also follows these laws, but the control or mental set determines the relative importance of each connection, making some associations effective and others ineffective in steering the course of mental life.

REFERENCES

Galton, F , *Inquiries into Human Faculty and its Development*, 1883.
Jaensch, E R , *Eidetic Imagery and Typological Methods of Investigation*, 1930
Robinson, E S., *Association Theory Today*, 1932.
Washburn, M F , *Movement and Mental Imagery*, 1916.

PROBLEMS

1 Make a study of imagery, using yourself and several friends as subjects and in general following Galton's method Take some scene which you all remember, and make a study of the form, color and movement of visual patterns (Probably one or two members of a large group will be found to have almost no visual imagery, they will probably recall in terms of words and attitudes rather than the actual picture originally seen Find just *how* they "image" visual material) To what extent are your own images and those of your friends probably affected by training? Do you find that your imagery is especially rich in those fields in which it has been given practice?
2 Give the free association test to a friend, preferably using the Kent-Rosanoff list of words if it is available in the laboratory Look up the "community" of the associations, and trace the origin of "individual" reactions
3 Write for two minutes all the words that come to your mind, starting with the word "psychology" Do it again, starting with the word "vacation" What value has this 'chain association" method in the investigation of individual differences in interests and personality traits?

CHAPTER XV

MEMORY

Memory consists of learning, retention, recall, and recognition.—When a person strives to remember a name and at last recalls it, we say he has remembered it This means more than that he has built up a skilled act. We mean that he has learned something, retained it, recalled it, and recognized it to be the thing he wanted. When we speak of memory, we take the first step, learning, for granted And our attention is usually given to the questions: how do we retain, how do we recall what we once learned, how do we recognize what we have recalled so as to say whether it is what we wanted or not? When you struggle to remember a name or a street address or the substance of an old argument, there is usually no doubt that you *learned*, that is, no doubt that an impression was made upon you at the time. The fact that you are struggling to remember means that there is some doubt as to whether you have *retained*. Sometimes you know you have retained but cannot at the moment *recall*; later the name or the detail may come into your mind without being asked for. Sometimes, too, several names will recur to you. You know that it is one of these, but not which one. Here you have recalled but not *recognized* efficiently.

The division of memory into the four processes of learning, retention, recall, and recognition will be clear if we consider four kinds of abnormalities in memory. For it is possible to find, in the clinic or hospital, patients suffering from damage to one of these four functions, yet normal in the other three. To be sure, two or more disorders can be combined, just as a person may have scarlet fever and appendicitis at the same time, but this does not abolish the separation between the processes involved.

The inability to learn is often found in a form of mental deterioration which appears in the very old, and to which the name "senile dementia" is given Most mental processes may still be fairly normal, yet the person can learn nothing new ("You cannot teach an old dog new tricks"). Aristotle, without knowing anything whatever about the physiology of the brain, made a curiously profound comment—that the mind is like a wax tablet, which in the young is so soft that impressions are promptly lost, but in the old is so hard that impressions cannot be made at all The old person who seems unreasonable or stubborn is often simply unable to accept a new impression, although what has once been learned in the days of mental vigor is well retained, and is also well recalled and recognized.

Retention may be affected in cases of brain injury from gunshot wounds or industrial accidents. If, for example, part of the brain is shot away, the person may recover to a fair degree, but certain commonplace things known before are now no longer retained, simply because the brain substance has been damaged

Failure to recall personal experiences appears quite commonly in normal people as the after-effect of emotional shock. The painful episode which the person simply cannot bear to think of is blocked off from consciousness and cannot be recalled We know with certainty that the impression was made, and that it is retained, because the patient may dream about the painful episode and talk about it in his sleep. Indeed, he may clearly recall it after he gets well.

Among certain groups of insane persons, recognition is badly disturbed Nothing is more distressing for a friend or relative than to find that the patient takes him for a stranger or even for a persecutor. Disorders of recognition, however, are also common in everyday life. We pass by some acquaintance and fail to greet him, or we hear a familiar tune about which we can recall many things without being able to "place" it. Another "disorder" of recognition, the feeling of familiarity when in places which we could not have visited before, is called "paramnesia." Apparently about half of the normal adult population is subject to this ex-

perience. The writer frequently has the experience of feeling that a new experience is really just a reenactment of something that happened when he was a little boy—frequently it is manifestly impossible that this could be the case.

The generally accepted explanation of these cases is that certain elements in the situation are identical with, or similar to, elements in some situation which really is perfectly familiar. Those inner responses which make up the "feeling of familiarity" are touched off by those elements which actually are familiar. In the strangeness of the new total, we fail to see certain details which would be recognized if they could be attended to separately. The feelings of familiarity are aroused unwittingly; they are touched off by unanalyzed elements in the total stimulus situation. The exact nature of the so-called "feelings of familiarity" is obscure, but they probably depend largely on kinæsthetic sensations

"Memory methods" include memory span, the method of paired associates, the prompting method, the method of retained members, the saving method, the recognition method. —Among methods of studying memory in the laboratory, the following bring out significant psychological principles. The *memory span* is defined as the maximum length of a series of elements that can be repeated by the subject after a single presentation (compare page 211) One may present a series of numbers or letters orally at the rate of one per second The numbers are given in haphazard order and without accent or rhythm Seven or eight letters represent the average adult memory span, although some individuals have a span of twelve or more Memory span is also tested by presenting materials visually Each stimulus is shown for the number of seconds corresponding to the number of elements to be grasped; for example, if there are five numbers or five letters a card is held up or shown on a screen for five seconds.

The method of paired associates is used to test facility in forming connections between pairs of items. This method throws light on the principles affecting recall of one member of a pair when

the other member is given. The life situations which most closely resemble the laboratory situation are those in which one needs to recall a telephone number in connection with a person's name, a street address in connection with a business firm, or a book in connection with an author. Our purpose in the laboratory is to simplify and standardize the conditions which underlie this general memory task. Words or numbers or other visual matter may be presented to the subjects Elements which are to be connected are placed on the same horizontal line and are separated by a fixed distance. A lantern and projection apparatus, or a tachistoscope, is customarily used. Instructions are given which emphasize the task of connecting the words in the form of pairs. For example, "I am going to present ten pairs of words. In each case the two words will appear together for one second. You are to connect them so that later when I show you the word on the left you will remember the word which came on the right Ready" After a few seconds for adjustment, the experimenter begins to present the pairs at an even rate. When all the pairs have been shown he prepares to test the subject's memory by sliding black covers over the right-hand side of the slides on which the words have been presented, or covering the right half of the tachistoscope slot. He then shows, one at a time, the first word from each pair; the subject is given a standard time interval, say four seconds, to recall, if he can, the word which was shown. The method has been widely used recently in teaching. Students who believe that they cannot easily form rote associations, as required in learning a language, are often surprised to find that by this method they can pick up six or seven German or French equivalents for English words in two or three repetitions of a series containing ten pairs. One reason why this is a good training method in language work is that instead of going blindly over and over material with which one is vaguely familiar, he is forced immediately, upon seeing the word, to struggle for the word which he needs The subject is thrown willy-nilly into the attitude of active recitation, and learns more rapidly while he is being tested than he could if the complete

pairs were shown him in succession, with no special requirements for performance on his part (compare page 293).

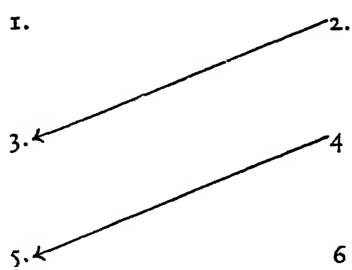
The prompting method and the method of retained members.—Though many of the materials which have to be remembered in life are of a rather piecemeal character, many other things have to be remembered in a coherent sequence Here the methods most suitable for the study of memory are those in which the subject gives attention to a whole sequence of terms for a certain number of seconds He scans the material as a whole rather than merely fixating pairs. Later he is asked to recall the elements in the order in which they appeared In the "prompting method" he is prompted whenever he falters, until he can go through the whole task without aid. In the "method of retained members" he is given credit for each item which he can give back, irrespective of its position.

In the saving method the subject is asked not to reproduce at once what he learned on a previous occasion, but to begin relearning. We measure the number of repetitions required to bring back the lesson so that it can be recited as well as at the end of the original learning. For example, the number of repetitions needed to learn a series of items may be thirty After an interval of two weeks the subject may find that he can recall absolutely nothing of what he has learned; nevertheless he may now require only twenty repetitions to regain the lesson to the point of a perfect recitation. Similar material which has been learned equally well at the beginning is not tested at this time but is tested later, say, after a total period of four weeks. In this instance twenty-five repetitions may be required If a large enough amount of standard material, of equal difficulty throughout, has been learned on the first occasion, the *amount of work needed to bring back the material* to the point of the original complete mastery varies with the time which has elapsed. In one instance an experimenter relearned material which he had memorized from one of Byron's poems twenty-two years before, but which he had completely forgotten He found that he could learn it more quickly than similar material from the same poem which he had never learned before. Much of the value of school and college subjects is believed to

depend on the possibility of rapidly relearning when the material is needed A trip to Europe, for example, may make it possible to make fresh use of what was learned in a modern language course which might seem to have been forgotten completely.

The recognition method.—Nearly always we learn more than we can readily recall. If a person scans a series of twenty disconnected words he may recall no more than half of them a few minutes later. Nevertheless, if the list is shown again he may recognize every one that has appeared. Recognition can be measured by presenting the learned items mixed together with a number of new items and requiring the subject to pick out those which he has seen before.

The strength of connections depends partly upon (1) learning by wholes, (2) spaced repetition, (3) active recall. —It seems common sense to believe that any two things which are experienced together will be associated together, as we noted above in connection with the traditional primary laws of association The law, as we saw, has a rough and ready usefulness. If we look more closely, however, we shall find that the law is not as simple as it looks Woodworth performed the following experiment. At the rate of one word per five seconds, one hundred words were read aloud to a group of adult subjects; as in the method of paired associates, the words were to be grasped as pairs rather than as elements in a continuous series Later, in testing the ability of the subject to recall each word which came next in the series after a given stimulus, Woodworth found that the ability to pass from the second element of a pair to the first of the next pair as shown below,



was only about one eighty-fifth as strong as the tendency to pass from the first to the second term of a pair which had been learned as a pair. Since the time interval from one element to the next was always five seconds, it is obvious that the mere contiguity in experience would apply as much to the connection between 2 and 3 in the series as to the connection between 3 and 4, etc. Thus, the law of association by contiguity, or really contiguity in experience, turns out not to refer to mere passive experience on the part of the subject, but to depend largely upon the subject's activity, his attentive connection of the two elements which are to be learned as a pair. Things must be attended to together if any really important connection is to be formed.

This last fact shows the blindness of the tradition of regarding the mind as a passive tablet upon which something is written We learn chiefly by setting ourselves to learn, not simply by being impressed. Not only everyday observation but much experimental work shows that we learn largely through a definite set or preparation to learn. Külpe, for example, showed his subjects a series of nonsense syllables in color. When they were "set" to learn the order of presentation of the colors, the subjects did this efficiently but were found to be unable to answer questions as to the letters in the various syllables they had seen When they were set to notice and report on the syllables, it was found that they had not noted the *colors*. Part of this set is a muscular matter; the muscles of the eyes, neck and trunk actually adjust us to take in the stimulus in a certain way. Whether it is *completely* a muscular matter or only partly so, there can be no doubt that this preparation or adjustment to the material which is to be learned plays an overwhelming part in most learning. This fact is one justification for the whole modern movement against parrot-like repetition and lock-step procedure in education If a great deal depends upon the activity of the subject, obviously individual differences in different subjects, ways of attending, their special interests, etc., will be not only worth noticing but an important aid to the educator Finding out how each individual can really attend best and feel actual

interest and significance in what is to be learned is more important than that solemn discipline which used to be so much emphasized.

Active recall is just as important as active learning Experiments like those described explain why mere rereading of material which has once been learned or partially learned is much less effective than the active recall of the material. If the material has been just barely learned the connections may be greatly strengthened by making oneself recall it in order. This is much more effective than mere rereading. The prompting method, as we noted, involves helping the subject only when he comes to a point in the series at which he cannot progress. He thus gets the maximum benefit of an active search for what he knows, and he is given help only at those points where he is stalled. The more the subject will do for himself, the more rapidly the consolidation of the material is achieved. In an experiment by Gates the learning of adults and children was compared in five different situations In the first situation each subject spent all his time reading and rereading his assignment. In the second he gave 80 per cent of his time to reading and 20 per cent to forcing himself to recall and recite, from point to point, what came next in the reading. In the third he gave 60 per cent to reading and 40 to recitation; in the fourth, 40 and 60, respectively; and in the fifth, 20 and 80, respectively. With both nonsense and meaningful material the more time given to reciting, the better the performance was. The apparent advantage of such recitation, great as it was immediately after the conclusion of the experiment, proved to be even greater when a retest was made four hours later.

It will be noted that in merely rereading, the attention is fixed upon a few central high spots in the theme almost in the same way that the eye fixates a few points in a line as one reads. Those connections which are not properly made in the first reading may fail to be supplied until much painful and tedious review has been carried out. If on the other hand one forces himself to recall, attention is immediately directed to the gaps or faulty connections. It is almost a self-correcting feature which permits the strengthening of the weakest link in the chain. Another reason

for the superiority of active recall and recitation over mere rereading is the fact that in reciting, whether to oneself or to another person, one is doing approximately what will have to be done later when the test comes. Whether one is his own examiner or is preparing material for an examination to be given by someone else, the task which he will later confront is like the task in active recitation, not like the easy-going task of the reviewer who needs only to read.

Another practical point is the proper spacing of the study periods given to each assignment. Just as working five minutes with the biceps muscle twice a day for six days does more to strengthen it than an hour once every six days, so, for any given memory material, repetition at intervals is more effective than continuous rehearsal. The best spacing for most memory material seems to be at an interval of from twelve to forty-eight hours. If, for example, an assignment takes an hour to read, it is better to read it again the next day and again on the third day than to read it three times in succession. Moreover, the principle of spacing applies also to very short intervals. For example, in a recent study by Piéron, repeating a short learning task every fifteen minutes proved to be more efficacious than the same number of repetitions of the task all jammed together without a rest.

In most cases a complex pattern which is to be mastered as a whole, such as the sequence of events and ideas in a chapter of history, is better learned by going through the whole thing and getting it as a unit than by learning separate parts and then putting these together, provided that the length of the material to be handled is not so long as to entail actual fatigue. It is better to give a certain amount of time, say, two or three hours, than it is to take it in pieces of twenty or thirty minutes each, starting off each time at the point where the previous study stopped. Superficially, it might seem desirable to break up the whole pattern, as in this way it would seem to resemble somewhat the result obtained by "spaced repetition." The two cases, however, are quite different. Any given *unit* of material is better learned by spacing than by continuous repetition, but any given

unit of material is also better learned as a whole than by chopping it up. If, for example, we are dealing with a history assignment which might take an hour to read, and if we have three such assignments per week, it is much more efficient to read the week's assignment as a whole, and later, after an interval, review it, than it would be to read each one twice in succession. And it is also much more efficient to read it as a whole each time that one confronts it than it is to get it by pages or paragraphs, studying each piece over several times and then going on to the next. The superiority of whole learning over part learning varies a good deal with the type of material, and it also varies somewhat from person to person It is, nevertheless, sufficiently well established to be of value to most individuals in most cases. The chief reasons for the superiority of the whole method seem to be first, the avoidance of associations from the end of one part back to the beginning of the same part; second, the fact that by the whole method the pattern is better grasped and each part is seen in the light of this whole pattern The part method, on the other hand, almost always leaves the meaning or plan of the whole as something irrelevant to be picked up at the end, so that it is much less likely to get the attention it deserves. By the whole method each word or phrase has some meaning because of its context in relation to the whole plan.

Despite the superiority of whole over part learning, there will always be cases where the student strikes a snag here and there and the repeated study of the whole may fail to do much to eliminate these difficulties. It is worth while to stop and work on individual parts which are especially difficult after the scheme of the whole has been clearly grasped. It is, in fact, better to combine the whole and part methods, giving each one its due, than to press the virtues of either one to the complete exclusion of the other.

Any list of principles for effective learning must consider to what use the learned material is to be put. Material which is learned for immediate recall tends to be forgotten rapidly; whereas under the same external conditions the subject who learns for

delayed recall, knowing that the examination will not come for a week, presents a less rapid falling off in the material retained This is due partly to the fact that in the learning in which the subject foresees the later task he puts himself into the position of fighting to recall material which is only dimly present Partly, however—and this is probably the chief factor—the subject who knows that he is later to be tested allows less interference from later activities; whether or not he has consciously kept the material alive during the week, he is on his guard against making connections which would break up what he has learned. Possibly, too, he will mentally review the material from time to time even if he does not intend to do so

When the meanings of words introduce irregularities in the study of memory, nonsense syllables are used.—Since the *meanings* of words not only differ for different people but cannot be directly measured, students of memory have resorted to standardized lists of "nonsense syllables" which as far as possible have no meaning: JEB, ROF, TOJ, SAF, KOL, and the like. All the memory methods can be used with meaningful material, but often the results show large individual differences between persons because of the difference in the personal significance of the meanings.

There are, moreover, many cases in which the use of meaningful material gives results quite different from those obtained in the rote learning of meaningless material. A good illustration arises in connection with this question· When we learn any five elements which we may designate by the numbers 1, 2, 3, 4, 5, do we simply form the connections 1-2, 2-3, 3-4, etc , or do we in the process of memorizing inevitably learn also the connections represented by 1-3, 1-4, or even 1-5? And do we at the same time, whether we know it or not, form backward associations from one element to another, for example, 2-1, 3-1, or 4-1? Ebbinghaus made up memory material by taking every second element from a series of nonsense syllables which he had previously learned For example, having learned 1-2-3-4-5-6-7-8-9, he made up a series of elements, 1-3-5-7-9. He found that the new connections formed

were learned more rapidly than were similar connections made up with nonsense material which had never before been connected. The elements which had appeared in the order 1-3-5-7-9 were learned in much less time than that required to learn five new ones, let us say, 11-12-13-14-15. Lists were also made up by selecting every third element, every fourth element, and so on up to the case in which seven elements were skipped, 1-9-17, etc. As the number of skipped elements increased, there was a progressive decline in the superiority of such lists over lists of the same sort of material in which all the connections to be made were new Lists of nonsense syllables previously learned and now placed in *reverse order* (5-4-3-2-1) were learned more rapidly than new lists These investigations are referred to as studies of "remote forward association" and of "backward association," respectively Ebbinghaus argued that there must have been some real learning of 1-3, 1-5, 5-4, 4-3, etc, when the subject was merely intending to learn the straightaway series 1-2-3-4-5 He believed that dynamic associations were set up not only between two things which were directly connected but between things which were separated by several elements in the sequence of study, and also that backward associations were formed This seems on the surface contradictory to the Woodworth experiment mentioned on page 291. Actually, however, Woodworth did not prove that remote forward association and backward association were completely absent And Ebbinghaus found a large difference between the association of terms which came together in the series and the association of those farther apart

In contrast to these results of Ebbinghaus, a recent study by Cason indicates that backward association does not appear at all in meaningful material. Remote forward association not only fails to appear in meaningful material but is actually present in a "negative amount"; that is, the material made up out of elements which were previously separated by some distance in the original material is actually *harder* to learn than the control material. The original meaningful pattern which has been learned makes

it more difficult to connect the materials which are put together in a different way.

From studies of this sort it seems reasonable to believe that the elementary laws of association which hold for nonsense material need considerable modification when meaning enters the picture The elementary psychological laws based on nonsense syllables are probably very important as offering us general clues for the disentangling of what happens in the task of learning, but it is a long way from these simple principles to those which we handle in most life situations in which meanings have to be connected. Suppose, for example, we made use of the principle of backward association in the more serious learning of meaningful material; we should probably come to grief. Whether or not backward association exists at all in meaningful material, it is certainly slight in comparison with ordinary forward association. This is, in fact, a very important difficulty in studying many kinds of material. We cannot foresee in which direction the material will have to be recalled. One learns a sequence of events in a given pattern: A gave rise to B Not foreseeing that we may be asked to say what was the cause of B, that is, to recall in backward order, we find ourselves stumped. Teachers of history know that it is not enough to teach that the Spanish Armada was sunk in 1588 in order to give 1588 a meaning of its own, or even to give a general idea of what was happening late in the 1500's; the student may have learned this and yet the question, "What happened in 1588?" may produce only confusion. An illustration from everyday life is forgetting where one is in the midst of a story, and finding that although many details are vividly remembered one cannot work backwards from them. He must dip in different places in the story until the place is found at which he can work *forward* until the desired point is discovered.

Meaning is a help in learning and helps prevent forgetting.—It goes almost without saying that in science or any orderly pattern of thought, the grasping of meanings is an enormous aid in fitting details together, and that the first task of the efficient

learner is to make the utmost use of meanings. Indeed, all the specific memory techniques are based in large part on this fact. This is even clearer in the case of long-time retention than it is in retention to the time of a final examination. What is learned by rote may often serve reasonably well for a short time, but may be crowded out by other interests and meanings as months pass. Meanings are more likely to tie up with life purposes and with other interests. They are, moreover, a primary factor in giving that degree of vividness which is one of the first factors in making for an effective connection between any two items.

There is, in fact, much experimental evidence that a great deal which passes for rote association, obeying the elementary law of association by contiguity, etc., really has some meaning in it, and that the learner characteristically uses all the mentality he has even in the simplest task. Arbitrary groupings, or the assignment of meanings to nonsense material, happens even when the experimenter tries to prevent it. All sorts of artificial aids are made use of by the learner of rote material. A case of this appears in learning the stylus maze (page 231), in which there might superficially be a mere rote connection to be formed Even here it is characteristic to try to use one's head and to learn the pattern in terms of words, "once to the left, twice to the right," etc.; and, in more complicated mazes, to try to make an intelligible pattern out of the whole, seeing whether there is some symmetry or plan in the construction of the maze. All this evidence justifies the emphasis upon the importance of getting meanings as one learns

We have described the *curve of learning*. There is also a *curve of forgetting*. It is best prepared from the data of the saving method (compare page 290), and shows how many repetitions are needed at a given time to bring the material back again.

The curve marked "reconstruction" in Fig 81 is reasonably accurate for nonsense material which has been learned just barely to the point of perfect repetition. Meaningful material, however, is forgotten much more slowly than nonsense; the curve is less steep. Material which has been *thoroughly* learned sticks much better still. Learning a thing beyond the point when it can just

barely be recalled is designated "over-learning" The term does not indicate that too much learning has been done; it means that the individual has gone beyond the point where the thing is technically just learned Under some circumstances a thing may be over-learned to such a degree that there is no falling off of that material for a long time as shown by the saving method.

It is of course the enormous superiority of over-learned, as compared with barely learned, material which constitutes the scientific

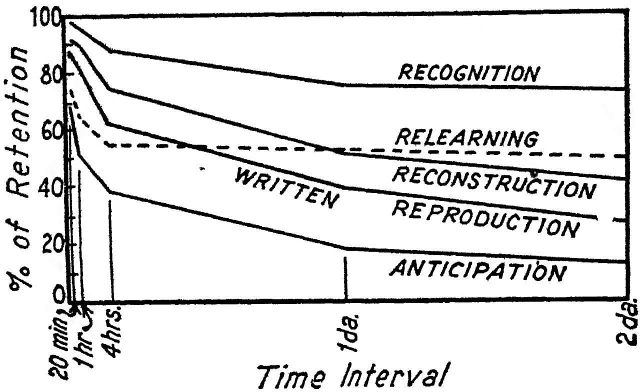


FIG. 81.—Retention curves derived from the different memory methods Note especially the form of the "relearning" curve (derived by use of the saving method, p. 290) The material used in this investigation was nonsense syllables barely learned After C. W Luh, *Psychol. Monog*, 1922, vol 31, whole no 142, p 22 By courtesy of the editor

basis for skepticism about the value of quick methods and short-cuts in study and in all mental work which involves learning There is no moral argument against cramming; and if the only purpose of the student is to attain a respectable grade on a final examination in a subject to which he hopes never to return, the more cramming the better What is retained five or ten years later, however, is so unlike what is learned at the moment before the examination as to appall even the experienced teacher. With such objective methods as we have, it appears that about a year after the average college course is completed, far more than half of the material is gone, even when tested by "recognition"

methods which only require that the subject indicate which of various things is the right answer to a question—that is, picking out the right answer from a series which includes several wrong ones. Psychology is among the college courses which have been studied in this way in terms of their retention value. Five years after the completion of a course it appears that those who have taken the course do only slightly better than those who have never taken it and merely guess at the answers; here, however, our data are not very extensive. Of course, even these results do not mean that the students who took the course five years earlier could not relearn the material; and by the saving method they would certainly have done better than a control group who never took the course If the main value of taking a course is to be able to relearn it many years later, then much has been accomplished by it But since most students never have a chance to review the material they took years ago in college, this is usually a far-fetched argument. On the other hand, what is over-learned and kept in a condition of over-learning by constant reflection, application and connection with new subject matter, has a chance of becoming a part of one's permanent mental furniture. It is this kind of psychology which most psychologists are interested in teaching.

We have discussed above the meaning of smooth learning curves and have seen that there is some mathematical truth in these general expressions, just as there is in a physics formula. However, each particular event differs from the generalization The beautiful simplicity of the curve of forgetting may cover up a great deal that is important to know. Consider, for example, the fact that the rate at which a thing is forgotten varies with the time of day at which it is learned Nonsense material learned in the evening is remembered much better the next morning than would be expected in terms of calculations made on the basis of waking hours The amount forgotten between 8 a.m. and 8 p m is much greater than the amount of material (equally well learned) forgotten between 8 p.m. and 8 a.m. Things are not forgotten through the mere passage of time but through actual

interference from thousands of other things with which we are occupied. Mathematical laws may be found for learning, but it is certainly not sound to use the same formula when comparing an active with an inactive state of the body, and it is not even sound to apply one formula for all of our ordinary waking life, simply because the mind never really relaxes or "stays put." For example, there do not seem to be "plateaus" in the process of forgetting when we compute the forgetting curve from a large amount of data; yet our whole method of smoothing out irregularities may conceal these and other variations. We may under some circumstances actually forget in large lumps. This does not mean that the general quantitative laws are not important. They are of great importance as generalizations when disturbing factors are disregarded It is merely necessary to caution the reader against feeling that any deviation from such a law indicates a freak or sport of nature.

Studies of testimony show that we usually recall only what we have noticed.—Very little of what is clearly observed and fully attended to is remembered twenty-four hours later Everyday observation will convince the reader that he cannot give a very good account of the traffic through which he passed yesterday, though he had to pay close attention to it in order to keep from being run over. Laboratory experiment yields an abundance of evidence that testimony is appallingly incomplete and inaccurate, even for things which were clearly observed Very few people can testify at all accurately about the size of a dollar bill or tell the number of columns on the nearest post office or bank building; very few can even give a correct description of the eye color, hair color, complexion, height, etc., of their close friends. Since this is true even of things which are easy to observe and which momentarily are observed by us all, there is no reason to be surprised that we remember almost nothing at all of the things that are *not directly observed*, things which never get into the focus of attention. If a complicated event happens in front of us, we cannot possibly see more than a small part of it. Yet strangely

enough we still continue in our courtroom procedure to assume that persons somehow remember whatever went on in front of them. We assume that an eyewitness knows what he "saw with his own eyes." If human observation were anything like this, the outcome of legal procedure would be utterly different from what it actually is.

It is the nature of human observation to be primarily selective, and the process of picking out things to notice means making oneself blind to everything else. In experiments, subjects prepare themselves beforehand to notice certain things, or have some idea of what is going to happen; and things which are not thus prepared for are not recalled even when the subject is alert to the purpose of the experiment (compare Külpe's experiment, page 292). If a picture is briefly shown over and over again, one may, by a series of "pounces" upon different parts of the picture, gradually find himself able to answer new questions much better. But in general one remembers not by calling up a mental picture but by getting hold of certain items, by saying them to himself, tracing outlines with the eyes or making some other definite response. One will usually remember exactly what he has noticed, and nothing more. Even five seconds after the observation, things not directly noticed cannot be reported upon. It is scarcely surprising that weeks or months after a crime, things which have never been directly observed, all-important details in the identification of those taking part in the action, are reported in fantastic form. Moreover, a great deal even of what was clearly noticed has disintegrated in memory.

At one of the International Congresses of Psychology a man ran into the hall shouting, fired a revolver, thus creating confusion, and disappeared Members of the audience were required to give an immediate report of what was seen, noting particularly the things of which they were so sure that they would be willing to swear to them They reported and were even willing to swear to much that never happened. Strange as it may seem, trained observers are often worse at such tests than more naïve observers, perhaps because training has narrowed them to par-

ticular things to be observed, and has created artificial blind spots Houdini, perhaps unkindly but probably correctly, said that among all groups he had studied professional psychologists were the easiest group upon whom to work sleight-of-hand. They were alert, but alert for the wrong things. From a recent study it appears that even children of rather low intelligence can observe certain things better than average or superior adults This, of course, holds only for accuracy of recall when there is no gross factor making for distortion. If we add another factor which appears in the court room—the cross-examination—we introduce a fresh source of errors. Anyone may be led into a false story by the phrasing of a question; and here we have many evidences that the lower the mental age the greater the suggestibility and the likelihood of being trapped into confusion or misstatement. Deliberate misstatement is only one of a large number of factors making court-room testimony unreliable.

Above and beyond all these general principles relating to testimony are the individual differences, *between persons,* in observing and reporting, depending upon their whole personalities and individual mental habits. For the last thirty years Stern in Germany has studied the psychology of testimony from the point of view of discovering not only the degree of accuracy in various types of reporting and the main sources of error, but also the ways in which the idiosyncrasies of different individuals cause them to see each event. In a certain sense the whole personality of the observer reflects itself in what he sees and in what he remembers. A certain kind of person is interested in or alert to certain things; when they happen he sees them; even when they do not happen he can hardly help seeing them. In the same way, what has been seen is recalled in a different way by each person in accordance with his basic psychological make-up. Stern believes that it is not enough to discover the laws of psychological observation and reporting, but that allowance must be made for the individuality of each observer.

With elaborate precautions Stern conducted an experiment in which a "crime" was staged for artificial purposes. A picnic party

near a road was suddenly interrupted by cries for help, and in a moment witnessed, as they believed, a murder The police immediately appeared, and the arrest and first taking of testimony were carried out so realistically that the members of the party actually believed that their testimony would be used in the legal procedure. In giving their testimony each one of sixteen persons not only showed great differences from the others regarding essential facts in the narrative, but displayed his own peculiar interests and habits of mind. The psychology of testimony, Stern believes, is really the psychology of the whole individual witness.

The "faculty psychology" once taught that it was possible to strengthen general faculties like "memory" and "will."— Thirty years ago educators were much concerned with the problem of "formal discipline." Many of them thought that one should take Latin in order to train oneself in habits of study, mathematics in order to train oneself in accuracy, and English literature to awaken one's æsthetic sense. The "faculty psychology" (the idea that the mind possesses a number of independent powers or faculties) was easy to discover in such views. The æsthetic sense was regarded almost as a sort of muscle which was to be strengthened by use. The student who learned to find beauty in Milton could find it in Walt Whitman. He whose accuracy had been drilled by calculating would be a more accurate student of history. He whose logic had been strengthened by Latin would fall into no serious pitfalls in his political thinking. Experiments showed, in fact, that training in one function might have a beneficial effect on another function or upon the same function carried out in a different part of the body. Skill acquired by the right hand was found to be present in the other hand when first used. Visual discrimination with one eye resulted in almost perfect transfer of discriminatory skill when observations were made by the other eye. Various theories which were in vogue (which looked upon the mind as a series of pigeonholes or compartments) seemed to be in accord with this doctrine of formal discipline. According to these theories, if you train a function located in one "part of the mind," all other functions which are

located in the same part will be strengthened because a basic mental faculty has been trained. This view was so prevalent that school and college procedure was actually governed in part by the attempt to apply it.

What is learned in one situation may be applied in *similar* situations.—William James found, nevertheless, that much memorizing of poetry had not resulted in any general strengthening of memory Thorndike and Woodworth trained their subjects in estimating the areas of geometrical figures and the magnitudes of weights, and in general found that when larger areas or heavier weights were used almost nothing was carried over from the first tasks to the second, except certain specific "identical elements," specific habits or techniques for handling these types of situations. A person might be able to discover just what techniques were helping him toward more and more accurate estimates; but except in so far as specific techniques could be carried over and applied in the new situation, no general increase in the power or faculty of accurate estimation of areas or weights could be found. If this held true for closely related things such as estimating the size of small areas and of large ones, it seems difficult indeed to see how learning to estimate areas could help one in arithmetical work or, in general, how any school subject could help the individual in an entirely different situation. The theory that we could teach formal capacities like "accuracy" and "concentration" was driven from the field as the result of many researches along these lines.

What can be transferred? There remained two important problems. First, what is an "identical element" present in two learning situations? Second, what makes it possible to use an element which has been learned in one situation, when confronting a new one? In answer to the first question, it has been recognized by practically all experimenters that the use of words—saying to oneself how one should tackle the problem—may be of value in a new situation even though the situation is very unlike the one in which the technique was picked up. The identical element may not appear in the *externals* of another situation, except in so far

as both situations are presented by a given experimenter in connection with a given psychology course; but the subject may nevertheless learn something about his own strengths and weaknesses, how to hold his attention on laboratory tasks, etc In answer to the second question relating to the transfer of an element which has been learned, it is clear that the degree of transfer depends upon the subject's general intelligence, upon the number of words which he has ready to apply to a given situation, and upon many details governed by his life history, such as his special interests and habits of observing

A further point regarding the term "element": the term must not be used to mean a lump or chunk of something It is often a way of behaving, not one fixed act. Thus, learning to sing a song in one key may give almost perfect transfer to singing it in another key, although the actual contractions of the vocal cords are all different. Thus, also, we can use a newly acquired verb in a thousand contexts with all sorts of variation of mood, tense and number.

The identical elements which are transferred are often the last ones we might suspect. A recent experiment with animals is very illuminating in relation to this point, for the transfer of learning from one maze to another shown in this experiment was large, and suggests that the animal was not reacting to the mere similarity in the plan of the two mazes. Jackson demonstrated that sheer handling of the animal and getting him used to the experimental situation is very important, regardless of any experience with mazes Even carrying a rat around in his pocket produced a large "transfer", these animals learned mazes as well as animals which had already had maze experience, and much better than animals which were entirely new to the laboratory. The animals did not merely learn about mazes, they became adapted to the laboratory situation as a whole In the same way, a good deal of human transfer is due to a new way of approaching a task, a whole new attitude which makes the job easier.

In connection with transfer one thinks of negative transfer or interference One kind of skill may sometimes interfere with the

acquisition of another, and this interference is often greatest when a half-learned task is followed by a new one more or less like it. However, in most cases where interference has appeared, it has been possible to practice both tasks to a level of such high efficiency that they no longer interfered at all with each other.

If a learning period is followed directly by some new task, this new task subtracts somewhat from the value of learning; we cannot recall the material learned in the first period as well as we should if a rest period instead of a second task had been interposed. This kind of interference is called "retroactive inhibition." Learning-period A will give much better results in the period C if B is a rest period rather than a work period.

A———C
B

The amount of difficulty in the later performance (C) of the A material, with B a work period, will depend largely on the degree of similarity between A and the intervening activity B If activity B is quite different from A, the period during which it is carried on may have more or less the effect of a rest period; but if activity B is closely similar to A, the retroactive inhibition is likely to be great. Nevertheless, the evidence from the studies of the similarity factor suggests that interference in the process of *recalling* the A material, rather than interference in the process of learning or in the retention by the brain, is the chief source of the trouble.

The *training of the memory* has become a rather sore point with psychologists, because so much buncombe is written on the subject; yet there is no doubt that a great deal may be done if one takes the trouble. What one gets out of a "memory training system" will depend largely on what he puts into it If, for example, it is vitally important to remember names, and if one is willing to make the effort to pay close attention to a name when introduced to a person, he can accomplish much in improving his memory for names There is no need to consult a

memory-training expert to find what particular sort of memory system to develop, because, knowing his own mental habits, one can make up a good memory system for himself, suited to his own needs. For example, if good at remembering *words*, but poor at remembering numbers, he may assign a letter to each of the ten digits and make up words which contain these letters in the right order. Or, if his mind's eye is rich in imagery for pictures, he may have a picture for each number, and work out scenarios of pictures whose sequence means a sequence of numbers; this type of device may be used to help remember street addresses or telephone numbers. If it is really worth the effort to do this, one need not be ashamed of it. The degree of success achieved will depend upon one's enthusiasm and energy. Even if one desires merely the pleasure of recalling names and numbers with special facility, it is worth the effort to train himself on these lines But he need not envy someone who "knows 200,000 facts," unless knowing 200,000 facts is worth its cost in time and energy

In using pictures for syllables or numbers, the result is often rather amusing. Suppose, for example, one wishes to remember the name MacErwin. One may see a picture of a *Mack* truck skidding along, that is, *err*-ing, but getting back on the road in time to get the goods to market, that is, so as to *win*. For every syllable one has learned a relevant picture. On meeting Mr. MacErwin one forms in a second the picture of the truck, its skidding, and its successful arrival. Good visual images may also easily be aroused by such common names as Carpenter, Smith, Taylor, Miller, Butler, and Cook if one thinks of their origin as occupation-names. Other less common names like Townsend, Richman, Morehouse, Fairchild, Churchill, and Greenfield may easily be linked with equally vivid mental pictures. Learning how to remember involves a specific skill acquired by practice like anything else. As in the case of sports, there is a certain native endowment which limits what one can do; but incentive and interest will raise one a long way above the dead level that would be maintained if one were indifferent. Usually the more fantastic the mental picture is, the more effective it will be.

Effective memory training is training in noticing, organizing and using new material.—The main need is to learn certain *principles of study.* For example, in connection with all memory investigations, it is important to remember that the true learning of most subject matters depends upon spacing one's study so as to *review* at the right intervals; or, best of all, to review them by using them. It is safe to say that our teaching has usually overlooked this point, with dismal consequences Many teachers and students assume that in some way what has once been thoroughly known is a permanent possession. We go on with our educational system like ostriches not wanting to see For example, we learn psychology with the idea that when the lessons are completed something has been permanently acquired. But one of the first tasks of a human being, as of any organism, is to put aside the things which it does not need in the process of living. The psychology that is systematically *used* from the minute it is first learned will, of course, never be forgotten If the time at which certain material will actually be applied (whether "practically" or for the enrichment of one's leisure time) is rather remote, there are two possible devices which may be used to keep it from being forgotten. The first is to go back to the material at regular intervals, giving oneself an examination or having another person give an examination on things that may be beginning to slip from the mind, constantly reviewing, keeping alive, and thinking over the principles. In this way after a considerable time, probably weeks or months, the thing will acquire a peculiar character, it will become almost second nature and will begin to "stick." A few years ago the writer forced himself to rehearse over and over again the names of, and many details about, the twelve cranial nerves, being fully convinced at the time that they would be constantly used in psychological work Actually they have seldom been used, but about once a year they come back with a flash They were "over-learned," trained to a point where they actually stuck A few courses, but only a few, were taught him in the same way in high school days These are always on tap although given little review Other things which he would greatly

like to remember, such as ancient history, are almost completely gone.

The other method is to make the subject matter so *vivid*, so compelling, so absorbing that one thorough exposure to it will protect one from all future forgetfulness. Unfortunately, we usually leave this matter of vividness to chance alone. A few thrilling picnics, a few horrible frights, a few jolly and a few miserable times are about all that most people recall from early childhood; and if we wish to recall things from the time we were six or eight years old we usually find that it is only things that were exceedingly vivid that have made any permanent impression, except, of course, the things that were endlessly repeated. It seems a rather remarkable commentary on our system of education that with a choice of material from the world's greatest literature, with much of the world's greatest music, with fascinating materials from history and from geography, most individuals remember nothing much but boredom.

In a novel by Anatole France, Maître Mouche declares: "It is not by amusing oneself that one can learn" Bonnard replies: "It is only by amusing oneself that one can learn. . . . In order that knowledge be properly digested, it must be swallowed with a good appetite."

Probably Bonnard is right. The relation of pleasantness and unpleasantness to the rate of learning and forgetting is an interesting one. There is some evidence that enjoyable material is learned more rapidly than material of equal difficulty which is not enjoyed Pleasant material learned in the laboratory is also forgotten much less rapidly than distinctly unpleasant material (though neutral material is forgotten most rapidly of all). That *pleasantness* is important seems clear. One English study involved the memory for a series of words; a report had been secured regarding the pleasantness and unpleasantness which the words evoked, supplemented by a galvanic record as to the physiological changes attending the original reading of the words (cf. page 107). The words having strong pleasant feeling tone were remembered better than neutral words, and neutral words better than un-

pleasant ones The galvanic records supported the view that the "neutral" words produced smaller physiological change than the pleasant and unpleasant. These results obtained in England were confirmed by results with a student group in the United States, again using galvanic records.

To recapitulate, there are two good ways of learning such material as is included in this book: (1) methodical spaced repetition until the thing has been over-learned so as to sink in; (2) making it vivid by illustrations of the principles as one sees them effective in himself or others, or by any other device which will give richness, color, and reality.

SUMMARY

Memory involves learning, retention, recall and recognition. Learning of words or of sequences of images follows the same laws shown in motor learning; but in speaking of memory we must also emphasize the retention of what has been learned and the processes of recalling and recognizing it. Each of these four functions may be disordered without involving the other three. The memory span, the method of paired associates, the prompting method, the method of retained members, the saving method and the recognition method are used to compare the relative effectiveness of different ways of learning memory materials. The traditional laws of association are found to be operative when investigated by all these methods; but active learning and active recall, i.e., a mental set for learning and recalling, determine how these laws are to function in any given case. The superiority of whole over part learning is largely due to the activity of the subject and the organization which he imposes on his task Whereas nonsense materials give passive connections between elements a rather important place, meaningful material puts a premium on the subject's activity. The discovery of meanings helps both in learning and in recalling The study of testimony shows limitations not only in perception but in capacity for recall of things which have not

been attended to, and the systematic distortion of memory by individual expectation, desire, or bias. The learning of any given subject matter helps in the learning of related subject matter. Whether one task is related to another, however, depends largely upon the individual who is learning. The active discovery of similarities makes transfer possible. Memory training necessitates finding similarities between tasks, so that memory devices which have been practiced with certain materials may be applied even to new materials. Real memory training includes learning how to attend, how to organize, and how to use what is learned.

REFERENCES

Garrett, H E, *Great Experiments in Psychology*, 1930, Chapters III-VI.
Robinson, E S, *Association Theory To-day*, 1932
Valentine, W. L, *Readings in Experimental Psychology*, 1931, Parts II, VIII, IX, and X.
Washburn, M F, *Movement and Mental Imagery*, 1916

PROBLEMS

1 Write out a plan for learning this lesson, explaining the principles of which you make use.
2 Give examples of disturbances in learning or recall due to emotional factors, and try to explain the mechanism of these disturbances.
3 In what high school or college subjects that you have taken have you found transfer from previous learning? Describe the character of the transfer, and the reasons for it To what extent can it be explained in terms of identical elements, and what are these in each case?
4 How much transfer do you expect to have from this psychology course to any other courses you will take? Outline ways in which you could facilitate such transfer where you would consider it desirable
5 To what extent do you think transfer might vary with the degree of an individual's explicit awareness of identical elements in two situations?
6 Outline the facts and concepts which you have already learned in psychology that have helped you to understand better the material in any literature, history, or social science course that you have taken
7 Outline the facts that you have learned in any biological or physical science which you have taken that have helped you to understand psychology better

CHAPTER XVI

THOUGHT

THE human organism is, as we have seen, an expression of needs, interests, and directing tendencies, some of which are the results of inner changes, some of which are reactions to the world outside. In this way the problem of thinking and imagination takes on a fundamentally different character from that which we ordinarily assign to it. Popular psychology supposes that thought and imagination are names for certain sequences within a quiet inner sphere of mental life which can be studied without regard to motives, interests or organic conditions. Reverie, for example, is supposed to involve a complete mental relaxation; thought is said to flow along the lines of least resistance, or is like a river finding its way down a hillside. From this point of view thought and imagination would bear almost no relation to the more urgent problems of living; they might be luxuries which have come to men through good luck. If, as seems probable, man has evolved and survived because his needs are served by his more complex mental processes, the popular theory needs amending. There must be a relation between his practical needs and his ability to think It will be worth while to give attention to needs or motives in relation to the whole process of thinking.

In its *simplest* form, thinking may be regarded as controlled association. It involves a *present* stimulus and another stimulus which is remote either in space or in time or in both It can therefore be shown to fall under the same general head as the delayed response, in which both an absent and an observed stimulus are responded to (see page 248). Thinking of this sort is involved in the effort to recall a name which is on the tip of one's tongue, the

attempt to place a familiar face for which no name is at hand, the attempt to hold oneself to a uniform mental task like balancing one's bank account. This is rather a simple form of thinking, to be sure, yet it is by general consent included under that head.

The more *complex* phenomena of thinking are usually defined in terms of what the organism must do rather than of the way in which it does it. They are, therefore, defined in terms of the external environment and point to no one psychological process. The way in which a man tries to meet an unexpected and baffling situation in business or in his personal affairs is said to be thinking (unless, of course, he tries not to meet it at all, in which case his response is usually said to be emotional). He may, however, approach the task by an extraordinary variety of different mental techniques, with varying degrees of success. We shall have to see what goes on when baffling situations are confronted and what the individual can do with such situations. We shall not be likely to find just one "process of thinking" sharply separated from everything else in mental life. We shall, in fact, find that thinking depends on all the psychological processes which we have described.

Unconscious "sets" or "controls" guide the process of judgment.—Systematic experimental study of thought began about thirty years ago. In one experiment two weights had to be compared (cf. page 218). After the second one had been put down and the subject had rendered his judgment, he told what had gone through his mind in making the judgment. In some cases it was found that the judgment was made without any conscious balancing of two sensory impressions The second weight was judged heavier or lighter than the first in terms of its absolute quality. Of course, the first weight had made some record of itself in the body, or there would have been no basis by which the second weight could be asserted to be heavier or lighter, but the point is that judgment did not necessitate the presence in consciousness of the two things which were to be judged. Another conclusion from such studies was that subjects participating in such an experiment were in large measure controlled by *mental sets* which were not

themselves present in consciousness (cf. page 281). Another series of experiments, aiming to get more direct information regarding the nature of control, brought to light the fact that the contents of consciousness during experiments with the word-association test

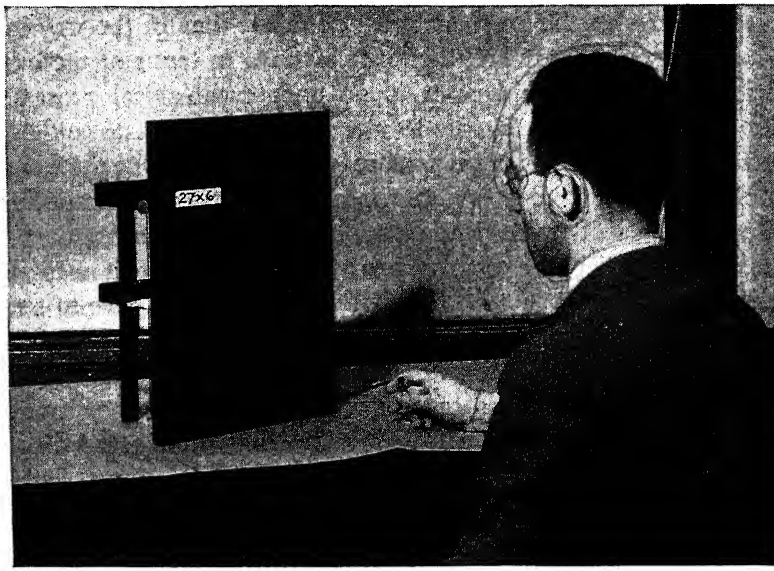


FIG. 82.—Exposure apparatus, devised by Minnemann. In some studies in thinking and learning, it is desirable to have the subject regulate the time of the exposures himself. In this apparatus, a series of problems, or other stimuli, are prepared on a stack of cards and so arranged, behind the screen, that when the subject presses the spring in his hand, the card which is at the window is pushed aside and the next problem is automatically presented. By a series of hidden electrical contacts, a record can be kept of the subject's time for each problem.

included no mental content to stand for the control. In other words, control was unconscious.

Galton found (cf. page 271) that many mathematicians and scientists with long training in *abstract* modes of thought were weak in *imagery.* His early findings are, in fact, of much interest in connection with our present problem. He even found artists of ability great enough to cause their election to the Royal Academy, who had no visual imagery. It is possible not only to copy but,

strange as it may seem, to "imagine" pictures in terms which are not those of visual images. Probably the kind of imagination these artists used was a sort of internal grasp upon composition, a sense of balance, rhythm, and so on, connected with the muscle sense; and it is even possible that a good deal which they had learned about color combinations could be successfully symbolized in terms of words which had been associated in the past with satisfying effects. Even so, these cases are puzzling to those who have vivid visual pictures, just as the imagination of a person born blind is taxed to the utmost to conceive what seeing may be like.

Perhaps the most remarkable aspect of such studies of imagery has been their demonstration of the many ways in which the same *thing* may be *thought of*. (For example, consider the cases of synæsthesia, page 274.) In a way, of course, the image is simply a symbol, but very different symbols may be used to mean the same thing. The meaning of a symbol is what it stands for in terms of action, i.e., its place in our own plans and purposes Meanings depend partly on attitudes or expectations, and these attitudes or expectations seem to be made up partly of muscular sensations. My attitude toward my friend and toward a hostile stranger is partly a question of muscular "set" toward them, as any observer would see if he looked closely at my posture and noted the tension of my muscles. The "meaning" of a piece of music is partly the way we are set as we listen to it. Whether this explains *all* meanings is a question not yet entirely settled.

There is necessarily much trial-and-error activity in thinking.—A number of experimenters have undertaken in recent years to describe thought in terms of its *processes* rather than merely in terms of its content. In one experiment the material consisted of mechanical puzzles and the task was to disentangle the component parts of each puzzle. The observer kept a record of the moves made by the subject as well as the subject's report of his experience. All subjects showed a considerable amount of overt trial-and-error behavior similar to that shown by cats in the problem-box In addition, however, they showed in their reports of their experi-

ence a large amount of *internal* trial and error. The process of trial and error carried on in the realm of the *inner* responses,

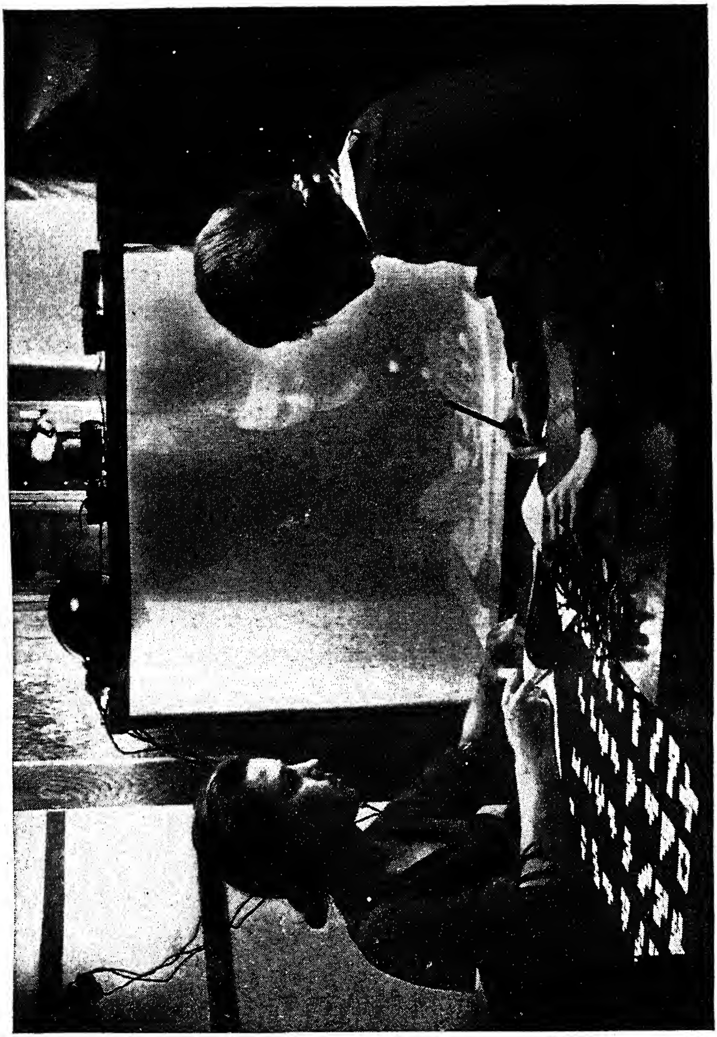


Fig. 83.—Study of thinking by objective and introspective study of puzzle-solving. To the left note-taker who records everything said; center, subject behind a "one-way screen"—she cannot see the experimenters; right, experimenter recording moves and times of their occurrence. Courtesy of H. E. Durkin.

or thoughts, seemed to be similar to the trial and error carried out in overt behavior. False steps were sometimes repeated and correct steps were often overlooked. (The experimenter found other

interesting kinds of thinking, but we must postpone consideration of these for a moment) Fig 83 shows a laboratory set-up by which such processes can be studied

A delay often occurred in an otherwise smooth curve as a result of an attempt to think out the problem. In these cases "thinking out" consisted of *internal* trial and error, without anything tangible to show by way of reward. It is possible in some such cases to reduce one's total time for the solution of the puzzle simply by stopping to engage in some mental trial and error at one point. However, one's *benefit* from stopping and thinking may sometimes occur at a different point in the curve from that at which the thinking process has occurred.

These conclusions from work with puzzles were confirmed by subsequent investigation with geometrical forms in which complicated patterns were presented and the subjects had to find out what these patterns had in common and how they differed. They had to identify the logical thread which connected all the patterns. Just as in the case of simple discrimination, the use of *verbal clues* proved to be of immense importance in facilitating the process of analysis.

Since similarities between problem-solving and trial-and-error learning are plentiful, an analysis of the reasoning process in terms of trial and error is one important and necessary study in laying the basis for a theory of thinking. Yet early in the process of restless exploration there are *persistent trends* toward one or another kind of activity. Behavior is not really "random." Interests and attitudes (which are really special kinds of mental sets) give special advantage to a type of response which has been effective in some previous situation. Here we have something which may be called a directive tendency or control. It is just like the unconscious control which we considered in the case of simple judgments (cf. page 315). Not only do such controls appear among the many random responses; in a sense, all the random responses may sometimes be mere variations of one main act of response. Thus when asked to fit blocks together in such a way as exactly to fill the space between two horizontal lines, subjects went back

again and again to a faulty solution, and even in some cases made all their responses within a framework which had been set by one false assumption as to the nature of the solution. Similarly, students working to find a way of suspending a pendulum from the ceiling seemed unable to use a hint from the experimenter unless it was in line with the directive tendency or "set" under which they were working. The search may presuppose a certain solution and a way of working toward the solution. This is like the hypotheses which we mentioned in the case of learning, and it is also like the hypotheses of the scientific worker.

Again, clear evidence for a directive tendency, together with a simple form of insight (such as we have described, page 255), appears in an experiment in which students had to solve the problem of tying together two ropes hanging suspended at a good distance from each other. The directions made it clear that they could use whatever materials they could find in the room. The task was manifestly impossible if the two ropes remained vertical —they were too far apart. About forty per cent of the subjects saw the solution but could not tell how it came to them, it came all at once. Another group saw how to do it after the experimenter had walked by one of the ropes, touching it, apparently accidentally, so as to start it swinging; but some of these insisted that no hint had been given; the idea of making one rope swing like a pendulum had come to them without their realizing that it was a hint. A third group failed altogether to find the solution Among the materials to be found in the room was a pair of pliers which, suspended as a weight, made it possible to swing one rope through a wide arc and in this way to catch it while holding the other rope taut at an angle. If we ask whether past experience affords the clue to such insights as these, we might at first be inclined to reply negatively; yet the experience of the subjects in the second group shows that the true answer is in the affirmative. In this case a flash of insight seemed to be a wholly *new* pattern, when as a matter of fact one essential part of the pattern had already been given in experience only a moment before.

A new idea usually depends on analysis and reorganization.—We noted above that human subjects in puzzle-solving showed much trial-and-error activity (cf. page 317). In addition to such processes, the experimenter found many instances in which wholes were suddenly broken into their component parts by a process which he called *analysis*. He used the term to include all cases of sudden regrouping or repatterning which confronted the subject while working on a puzzle. The puzzles seemed to break up or alter while being examined, exactly as we found visual patterns breaking up in the course of a child's perceptual development (cf page 178). Such processes of analysis, together with a fresh integration of the parts, often attend sudden improvement in performance. The object ceases to be a confused blur; it is broken up and the relation of the parts to one another and to the whole is clearly seen.

The general biological fact of transformation of a response, all at once rather than piecemeal, has already been considered in relation to attention (page 213) and learning (page 256); it is therefore not surprising to find it also in thinking. It makes an explanation of thinking in terms of "association" very unsatisfactory because the heart of the problem is the dynamic readjustment of a whole task rather than simply the independent shifting of the parts to make a new total.

The "flash" of insight may perhaps be more than superficially similar to a flash of lightning; it may be based upon a sudden shift of equilibrium or a dynamic readjustment in the brain. Just as lightning may dart about in many directions and then unpredictably strike a lonely tree in a field, so the brain may be subject to hundreds of slight chance associations and then suddenly make a basic adjustment. We cannot, however, accept the popular idea of "inspiration" to explain the cases of insight, because so many insights are really largely or completely wrong Those insights which work out well are likely to be remembered. The study of the processes of literary or musical creation, and of scientific discovery and industrial invention, shows that insights of all degrees of correctness and incorrectness are constantly occurring in

men whose minds are trained to deal with a particular subject matter Our best insights are usually obtained in relation to the fields in which we have acquired some skill. Close observation of oneself when playing bridge or checkers, or when planning some new venture in connection with one's work, will show that "hunches" and insights have to be criticized and reworked into new form just as anything in life has to be, if it is to suit one's needs

Even very small children are capable of analyzing and reorganizing their impressions.—We saw (page 255) ways in which reorganization of the perceptual field affects the process of learning. We may now consider it from a slightly different point of view, our interest being in the solution of a problem as a psychological question in its own right, aside from its part in learning

The reader will recall Köhler's experiments with apes (page 256). A similar study has been carried on with little children The general set-up was made as much like Köhler's situations as possible in order to study the relation of insight to trial and error. Forty-four pre-school children took part in two series of problems. The first series required climbing to reach a toy. A, the key situation, gave the principle to be applied to the rest. In this key situation a toy was suspended from the ceiling, too high to be reached. There was a block in the room which the subject could use to climb on to reach the toy; this was placed so that he could see both of them together when he came in, but he often got himself into such a position that this was impossible. Situation B was similar except that there was a small chair to be used instead of the block. In situation C the toy was put on a shelf, and there was a block which the child could use to climb upon In situation D the desired article was hung higher so that it was necessary to turn the block on end. Situation E required *both* the chair and the block

In series 2, an object was placed out of reach and had to be obtained somehow by the use of a stick In A, the key situation in this series, the child was placed in a play-pen and the toy was placed outside, beyond his reach; there was a stick in the play-pen

which he could use to get the toy In situation B there was a broom in the play-pen instead of a stick. In situation C there was a short stick in the play-pen and a long stick outside; the child had to get the long stick with the short stick, and then use the long stick for reaching. In situation D it was necessary to insert one stick into the other in order to get the object.

Every precaution was taken to keep the child interested and to keep him from being frightened. A desired toy was used to arouse interest and make sure of sufficient motivation Each situation was presented from one to five times, and if the child did not solve the problem by the end of the fifth time, the matter was dropped; only those who solved problem A, that is, the key situation, were tried again.

The responses to the problem situations might be grouped in several ways· First, according to presence or absence of an attempt to solve the problem. The attempts might further be grouped as direct or indirect Some of the children went directly ahead, openly trying to solve the problem, while some walked about the room, glancing self-consciously at the toy and came to a solution after much delay. The methods used in solving might be classified as: (1) Primitive responses: reaching with the hand toward the desired object; standing on tiptoes. (2) Random responses: all kinds of activity which had only a remote relation to what was wanted—this happened when the child was frustrated. (3) Exploration and trial-and-error elimination of false starts: the more difficult the situation, the more this response was called out. (4) Immediate solution. The more often this was called out and the more clearly the idea of using tools was established, the less frequent became the random responses.

Insight was identified partly through the child's ability to use what he had learned as he passed to a new situation, partly also by a change in expression or a revealing remark, such as "Oh, I see," followed by rapid solution. The solution itself is the criterion of insight The reorganization in the subject's mind was not necessarily *sudden*. There seemed to be cases of gradual insight: first an awareness of need; then an awareness of the means.

betrayed by some such behavior as picking up the stick or looking at it, kicking it, and so on; finally, seeing the whole field in its relations And there was "partial" insight, which evolved gradually, in contrast to sudden complete insight Sudden insight, moreover, sometimes emerged on the scene of action and sometimes at the beginning of the following trial, as though it had matured between trials or was due partly to some change in attitude

Insight, in the sense of perceptual repatterning, seems, then, to be found at an early stage in human development. Yet to find that such a thing exists is one thing; to tell when it will appear is another. As we have seen (page 320), we are often resistive to insights; a false start may blind the subject even to the trial-and-error possibilities which lie before him He may not only fail to show insight; a wrong "set" may prevent the appearance of the random movements which would solve the problem.

An experiment may throw some light on the *conditions* of insight. Forty students were given a set of blocks and a base on which they were to build up the blocks to just reach two horizontal bars. The blocks could be put only one way to solve the problem. The subjects were told to *handle* the blocks as much as they liked but not to build until they had completed a plan. They were allowed but one building trial. Forty other subjects were allowed to build *immediately*. They were permitted as many trials as they desired until they solved it or decided it was impossible. The trial-and-error subjects in every case repeated errors several times This in itself suggests that the degree of insight involved here was slight, both imagery and behavior seeming to be directed chiefly through the medium of trial and error. The task was not one in which the necessary background of experience was available, there was, so to speak, *almost no perceptual field to reorganize*. Insight, as we should expect, is dependent to a large degree on familiarity with the task; perceptual reorganization is subject to law as much as is anything else

Abstract thought depends on concepts.—Certain kinds of stimuli bring about roughly the same responses. For example, if

a geometrical pattern is varied as a conditioning stimulus for food, 100 per cent of the conditioned response may be aroused by each new presentation despite the experimenter's changes in the stimulus; but if the animal has been trained to one pattern and the experimenter makes a certain change. he finds that the situation is suddenly altered. The stimulus, so to speak, must keep within certain limits in order that the response may remain unaffected; if the stimulus departs more widely, the result will be quite different

In all such cases, one might speak of a tendency to behave in the same way whenever objects having certain similarities are presented Crows which are frightened by farmers who shoot at them have been said to have a clearly defined "recept" which makes any man with a gun or a stick a source of danger, and the scarecrow is effective because it falls in this general class of objects. But it is only when that quality which characterizes all the common stimuli for a given response is marked off and given a differentiating *name* or *label* that we can properly speak of the formation of concepts. If a specific gesture is used by a merchant to indicate values which look good and a different gesture is used to indicate those which look bad, his business associates may learn to give a name to the gestures which indicate that he is about to make a favorable or unfavorable decision. The merchant might not know why he felt as he did, nor realize that he always used the same gestures. He would then have a "recept" of a given sort of offer which is acceptable or unacceptable, but not a "concept." His associates, however, who understand better than he does the exact basis for his decisions, have put the matter into words, so that they have a definite "concept" For the most part, differentiating marks of this sort in the chaos of experience depend upon *words*; most concepts are words standing for a principle of classification which marks off one set of experiences from another If no adjustment can be found which applies to all cases and no word can be discovered which names the essential principle running through particular cases, then no concept can be formed We store up information largely in the form of words, and the way in

which we state it in words partly determines how we shall remember it. This is illustrated by the experiment from which

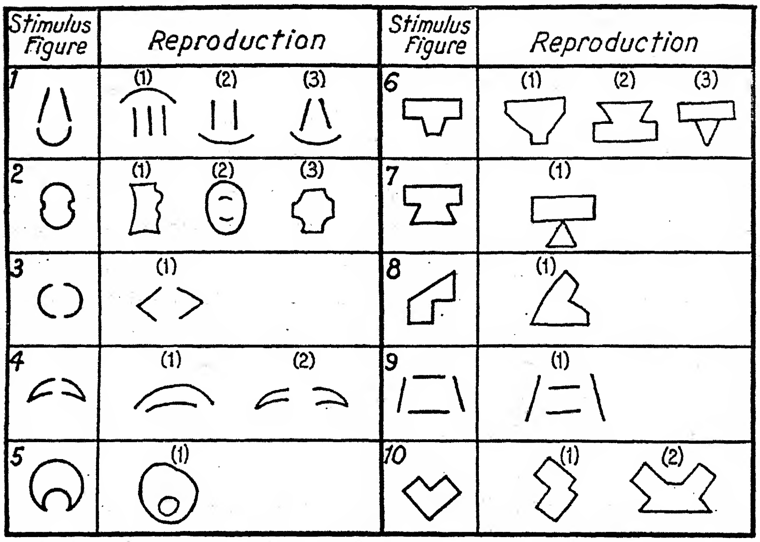


FIG. 84.—An experiment illustrating the importance of words in experience. Stimulus figures were presented to subjects who were later required to reproduce as many of them from memory as they could. Many of the reproductions were distorted, clearly showing the effect of the words which the subject said to himself at the time of the original perceptions. Samples of words used were as follows (compare the reproductions):

Stimulus
Figure

1 (1) Pillars with curve. (3) Megaphone in bowl.
2 (1) Thing with two little humps. (3) Thing with circles taken out.
3 (1) Two things facing one another.
4 (1) Half-moon disconnected in two places.
5 (1) One circle inside another.
6 (1) Sloped down. (3) Point with square on top.
7 (1) Square on triangle.
8 (1) Thing with an indentation.
9 (1) Two lines inside two others.
10 (1) Two rectangles fused. (2) Two things going up and out.

From J. J. Gibson, *J. Exper. Psychol.*, 1929, vol. 12, p. 19. By courtesy of the editor and the author.

Fig. 84 was taken. Here the subjects remembered things in terms of the ways in which they had *verbally formulated* what they

saw, that is, in terms of the concepts they had formed as they observed the objects.

The process by which concepts are formed may be illustrated by a simple game played with matches by two persons. One player takes either one match or two from a pile; then the other player takes either one or two. They draw in turn until the last match is taken, and the man who draws last is the winner In an experiment on the formation of concepts the experimenter (using beads instead of matches) played against each subject in turn and studied the gradual mastering of the rule by which the game can be won The principle is this: He who draws so as to bring the number down to *zero* wins. Therefore, he who brings the number down to *three* wins, because whether his opponent draws one or two, he himself can reach the desired zero In the same way, *six* and all other multiples of three are winning numbers. Consequently, if the subject begins with fourteen, he can easily win by drawing two so as to achieve twelve. The game was gradually made more complicated by increasing the total number of beads and by using numbers larger than three as key numbers In the process of struggling toward a generalization which would always win, the subjects at first tried to use imagery but, as the task became more complicated, reverted to the use of language: "Explicit generalization did not often occur until the number of beads presented was high enough to preclude the possibility of direct, perceptual foresight of the consequences of all possible draws, i.e., until the numbers presented were high enough to place a premium on the use of symbols in their solution"[1] (J. C Peterson). The subject, moreover, has much verbal material at hand which he can use in most such tasks.

When confronted with a series of complex geometrical figures, subjects were required to find the clue to the variation from figure to figure so as to predict what the next figure would be. The process of thinking stimulated in this way led to two fundamentally distinct attitudes which the experimenter called respectively "spectator behavior" and "participant behavior." The former

[1] *Psychol. Monog.*, 1920, vol 28. no 129, p. 81

was the quiet and passive observation of the panorama of figures, a mere waiting until some general clue came. The latter was the active search for clues. Both kinds of attitude led, nevertheless, to the sudden crystallization of hunches or hypotheses. Many of those which appeared were fruitful for further work, requiring only to be whittled into shape, and others were correct when they first appeared. In other words, trial-and-error responses appeared in some cases, but in other cases a correct response was made with a single stroke.

Concepts depend on words or other symbols.—In regard to the content of these hypotheses that come in the course of thought, it may be noted that some are definitely in verbal form, others in visual imagery, and a third group simply in ideas without further specification. Those verbalized are much more efficient when the problem of transferring what has been learned in one situation to the differing conditions of another situation must be solved, just as an exact verbal description of the way through wild and hilly country will make a correct decision as to when and how to turn more possible than a visual pattern of the way would usually permit. Words are far more numerous and their meanings infinitely more refined than gestures or other symbols; and the forming of concepts arises through learning to discriminate elements which belong to certain common classes, and giving names to them.

Though concepts depend chiefly on words, their formation is assisted by other devices. Images often serve pretty well; for example, a solution of the question of how many teaspoonfuls would make a pint might be roughly answered by visualizing if images were suitable. Images, however, even when perfectly clear, are not entirely dependable; they are too likely to be applicable to individual cases but not to *all* members of a group, and oversight of essential facts may result

One may get into some confusion in his thinking if the symbols are carelessly chosen. He may, for example, symbolize integrity by a visual image of a person standing erect like a ramrod or by the word "upright," and he may symbolize dishonesty by a picture

of something twisted like a corkscrew or by the word "crooked" Images and words of this sort must serve a double purpose, a literal purpose and a metaphorical purpose. One may suddenly discover that the deformed Mr. Blank is a person of the highest integrity, a point which for a moment requires an adjustment because one has been using the image or word without realizing that it was acting to represent a specific object and *also* as a concept-marker An image may lead to confusion if it symbolizes both literal uprightness and metaphorical uprightness, as in the case just cited

A large part of the process of manipulating concepts is made extremely difficult because of this *double* use of labels The abstraction "man" or "Mr A" is actually handled less efficiently in logical relations than is "Mr. Edward Jones" or "Mr. Harold Smith." The results of experiments in reasoning in which the same rational process must be carried through first with concrete and then with abstract materials show great differences usually in favor of the former. Reasoning does not depend merely on the ability to take certain logical steps, since the connections required to solve the task are the same in the two cases Yet the nature of conceptual thinking is not *necessarily* harder than concrete thinking, as is shown by comparing the relative difficulty of adding a column of figures and adding numbers which define particular objects To add 10 oranges, 9 oranges, and 6 oranges is certainly not easier than to add these numbers in their abstract form. The most difficult thing would be the *simultaneous* manipulation of the numbers *as abstractions* and as symbols for *particular things*. Far from finding that our thought must always be made concrete in order to be made accurate, we find that abstract thought like that of mathematics is often easier than the same thought with some specific content mixed in Difficult as the operations of mathematics may be, they would be much more difficult if in figuring the area of a county we had to have in mind all the farms, lakes, forests, etc., instead of reducing all of these to one simple abstract form, namely, "square feet." Abstraction,

the process of reducing all these things to measurements in terms of square feet, is necessary if thinking is to be clear

When concepts are formed they must be arranged in sequences to make patterns. It is this arranging or ordering of our concepts which makes up reasoning Concepts may tend, as images do, to be associated with one another by mere contiguity and similarity, without a guiding purpose or set. Characteristically, therefore, real thinking consists of steering a definite course, that is, getting away from the simpler mechanical connections based on past experience. We have to follow the laws of association and can, of course, work only with what we have learned to use. Nevertheless, among all the possible lines of thought the mental set enables one particular direction to be taken consistently

Children need years to learn to use adult concepts.—Studies have recently been made of the development of concepts in children It is a curious fact that with all the thousands of good minds devoting themselves to the education of children, so few educators have undertaken a systematic study of what goes on in the child's mind as he reflects on the world about him, the development of his understanding of other persons and of nature, the growth of his conception of himself as a person, his understanding of his own thoughts, fantasies, and dreams. Piaget, at Geneva, has systematically interrogated children from two to fourteen years of age, using standardized sets of questions presented in an informal way. He has tried to find out what the first words mean as the child utters them, how the child interprets the words which we say he "understands," how he accepts the notion of a "mind" and a "body" and of their relation to each other.

One of Piaget's most interesting discoveries has to do with the long and laborious processes by which the child learns to form concepts to distinguish "living" from "non-living" things. The little child is typically "animistic," that is, he regards animals, trees, and even inanimate objects as alive in about the same way that he himself is alive; but to be alive is for him at first the same as to be conscious. A tree, for example, is sorry when the

sun sets. A nail dislikes being pounded. At five or six the child passes into a second stage of development, in which objects are "alive" if they *move*; leaves, for example, are alive when they fly with the wind. At about twelve the adult mode of thought is reached, life being attributed only to animals and plants.

This animistic tendency seems to be partly a natural reflection of the child's stage in mental development and partly a thing which is imposed upon him by the ideas of the adults about him, the fairy tales and bedtime stories which he hears. It is granted that the social environment plays an important part; the European or American child tends to interpret most things about him in terms similar to those which he uses in describing his own acts. After all, from the child's point of view, why should a dog or a horse differ very much from a person in its thoughts and feelings? Piaget found that nearly all little children thought that animals could talk, and violently resented the attempts of adults to persuade them that animals did not understand what was said.

This is but one illustration of the kind of problems which Piaget has studied. Another problem is the child's interpretation of dreaming. Just as primitive man finds it difficult to distinguish between dreams and reality, and has been found to demand revenge for injuries of which he dreams, so Piaget's children are nine or ten before they realize that a dream is not an objective thing.

The ages at which the children are reported by Piaget to reach each of these stages of development may very likely be too high. We ought to know more about their intelligence and education. American children in favored communities pass through these stages earlier than the children reported on by Piaget And the stages are really not sharply marked off; there is an unbroken continuous transition from childishness to adulthood.

One of Piaget's services lies in pointing out the rather late development of "logical" thinking. Man may in a sense be a rational animal, but he certainly has to *learn* to think. In his studies of children Piaget finds an abundance of instances in which items are stuck together without a grasp of their true relation, and cases in

which a whole is treated piecemeal, as if it were several independent fragments One of his methods of study is to tell a story to one child, ask this child to repeat it to another, and get the story back again, thus modified by two childish minds. Faulty synthesis and faulty analysis appearing in these cases are attributed by Piaget to the child's absorption in his own interests and his failure to see things objectively; the child is "egocentric." Egocentrism reflects an inability to see things from a social point of view. There is some truth in this; but *sheer lack of experience* with the given subject matter is responsible for many of the logical errors. College students tested by the same story-telling technique showed the same tendency to distort the narrative; and the more difficult it was, the more it was distorted. The jumbling together of items without grasping their relation and the treating of wholes as if they were bundles of separate ideas appeared just as they did in the children; and as far as egocentrism is concerned, the students tried to make the narratives mean what they themselves wanted or expected them to mean, just as a child would. In one experiment, for example, a scientific account of the influence of climate on civilization had described the destruction of ancient cities. A student had been so impressed with the idea that man merely "discovers" rather than "invents" natural laws that the account of how ancient cities were buried in sand came out in the following form: "Just as if we were to find a hidden city buried the thing would have been there always, but we are just finding it out."

Our still surviving belief in the fundamental rationality of man is interestingly reflected in the fact that this tendency to think *what we want to think* or what we are "set" to think has hardly been investigated at all seriously. Psychiatrists have written of *autistic thinking* (thinking for pleasure or thinking which is its own reward; cf page 282), but for the most part the accounts are clinical, not experimental Yet the importance of this kind of thinking can hardly be exaggerated. Unless our whole view of thinking is woefully at fault, the thought processes are aimed, directed. not random; and hundreds of other aims besides the

achievement of true or "right" solutions govern our thinking In most tasks, even in the laboratory, self-esteem and self-justification play an important part. In a recent matter-of-fact laboratory task, subjects hated to give up a solution upon which they had hit, even when the evidence was clearly against this "solution"; and in almost every matching of wits there is more than a struggle for truth for its own sake One tendency which results in a great deal of false reasoning is called "rationalization" Rationalization is a way of making excuses to ourselves in order to justify those actions which might otherwise seem undesirable.

The levels of problem-solving may be reviewed. A little child tries to get all his blocks into his wagon. He pushes and pulls and squeezes. This is motor trial and error. An older child tries to think it out, imagining the space taken by each block. This method may involve inaccuracies, but it is probably better than the first method At a still higher level of problem-solving, recourse is taken to the use of symbols. The exact amount of material required to fill a space can be predicted by measuring the dimensions. It is clear that with more complex problems (e g., determining the amount of lumber needed in a house) the third method of problem-solving is the only one of which we can make practical use. The first level (motor trial and error) is overt struggle rather than thought. The second level (problem-solving through images of the material used) may be called a type of primitive reasoning; it is reasoning in that it restrains overt activity while the possibilities of action are rehearsed and evaluated. The third level (problem-solving through the use of verbal symbols) is conceptual thinking. Of course, these three types of activity do not usually occur separately, they interpenetrate, and even the most intelligent person frequently has recourse to the first and second methods. But it is undoubtedly true that as our behavior becomes more rational it becomes freer from mere motor trial and error, and falls more largely under the control of verbal rehearsals and formulated principles Man's special superiority consists in his power to deal

with symbols; the development of thought would be impossible in a world of concrete close-to-the-ground sense perception Most thinking requires conceptual labels, verbal signs which symbolically represent the real world but can be manipulated with much greater swiftness and economy than is possible in the overt acts of the animal or the baby Somewhat as our modern currency is a substitute for the cumbersome process of barter, so our language serves, rationally, as a substitute for motor trial and error Through symbols it is possible for man to react to abstractions and to expected stimuli. By verbal rehearsal (mental trial and error) he can predict the possible outcome of behavior, and make finer discriminations between the impulses which must be inhibited and those which must be favored.

There have always been philosophers who took the position that thinking is *dependent upon speech* or even that it simply *is speech.* It has often been said that meanings are dependent on words; and the fact that the speech organs are often known to be active during the thinking process has seemed to lend weight to such theories.

The "behavioristic" interpretation of thinking asserts that thinking is simply a bodily activity standing for action.— The behavioristic psychologist says not only that thinking depends upon language but that it is really nothing more than the inner use of the speech organs and other organs involved in the use of symbols. If we had fine enough instruments we could directly study these gentle movements of the speech organs, and according to the behaviorist we should then be studying thought itself The doctrine maintains that thought may be studied in the life history of the individual and may be shown to be directly derived from the *overt speech* of a little child As the child grows up, he is ridiculed or embarrassed to find that he cannot think as grown-ups do without talking aloud He may even betray his intentions. He learns to substitute whispered for spoken language, and shortly thereafter reduces his speech movements to a point in which the

motion of lips, tongue, and larynx is so slight as to be unobserved Apparently such changes occur at four or five years of age. No one seems to have shown that problem-solving of any sort is possible in a small child without definite spoken language, except in those instances in which the problem-solving consists entirely of a re-patterning of the perceptual field (see page 322). Certainly, the trial-and-error activities involved in thinking may be regarded as dependent upon an actual shift in the patterning of activity in the speech organs The two-year-old thinks aloud: "Let's try it this way. No, it won't go in. Turn it around. Now it goes in." So, presumably, he continues to do, even when whispered and finally internal speech replaces overt speech. From a "behavioristic" point of view, internal speech consists of actual muscular contractions which a sufficiently delicate piece of apparatus would record. Thinking is genuine change in muscular tension.

Early studies seemed to favor this view. If a subject said the word "ball," the movements of the tongue recorded on a smoked drum a distinct pattern characteristic of that particular word. When the subject was then asked to *think* the word, the pattern appeared in similar form but in diminished amplitude Even on the third and fourth thinking of the word, the essential form of the curve was still to be recognized A subsequent experiment found that tongue tracings of the sort just described appeared in only about five per cent of the cases recorded; that there were instances in which no conformity to the expected record was found, and even some cases in which the pattern should have accompanied an entirely different word Such records for the tongue would, of course, reveal but little as to what the other muscular mechanisms of speech might be doing; and, in the nature of the case, they cannot tell us to what extent other muscular changes in the body, such as those of gesture and posture, might occur (cf. Figs 85 and 86) The deaf and dumb think with their fingers to some extent. These movements usually appear in the thinking of deaf persons; and they demand, as the observations of the tongue movements do, detailed and systematic study Using the speech

muscles certainly does *directly affect some mental processes*; cf. Fig 85, which shows how much better memorizing was done with the aid of articulation. Note also how *thinking of a movement sets the muscles going*, as Fig 86 shows.

Another line of investigation which throws serious doubt on the muscular account of thought is one in which an investigator solved

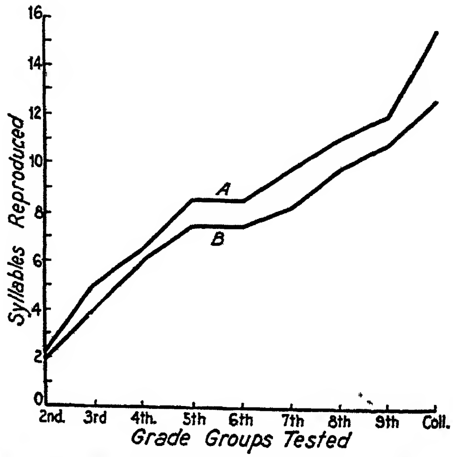


FIG. 85—The importance of the speech muscles in memorizing Children in different grades were required to learn lists of 20 syllables under two conditions *A*, making normal responses, and *B*, with restricted articulation. The curves show the number of syllables reproduced after studying under each of these two conditions. Notice that though the differences at any one point seem small, nevertheless in all the groups tested, those children whose speech muscles had free play averaged better than those with restricted articulation From M C. Barlow, *J Exper. Psychol.*, 1928, vol 11, p 310. By courtesy of the editor

problems while pronouncing the vowel ē in a monotone. He kept the whole speech apparatus in practically constant tension, but could think as well as ever. Experiments, then, though they are not decisive, seem on the whole to be against the purely "objective" definition of thought. The question is not whether thinking requires the brain; it is whether thinking requires muscular activity, and whether the muscular activity is the thought itself. The evidence seems on the whole against the view that thought absolutely requires muscular response, but in the writer's opinion the

question is open, and improved experimental procedure may perhaps change the picture.

SCIENTIFIC THOUGHT

When Aristotle laid down the principles of logic and set the fashion in logical theory for two thousand years, he had in mind the reduction of reasoning itself to certain simple principles. He showed ways of deducing specific laws from a knowledge of general principles. Three centuries ago Francis Bacon emphasized, on the other hand, the techniques of collecting facts and the principles of inductive reasoning by which large quantities of observations are made to yield valid general laws. Instead of working from general principles to particulars, he sought to prove that the important thing is to get plenty of particulars first and allow the general principles to emerge from them. Bacon's work was contemporary with the inductive studies of Galileo in physics and astronomy, and Harvey in biology, and many scientists began to distrust the older deductive methods and to seek for the foundations of knowledge in the collection of particular facts from which general laws could be established.

About a hundred years ago John Stuart Mill set himself the task of showing the intimate relation between psychology and logic, founding a systematic science of logic upon two great substantial pillars: one, scientific method as shown in physics and chemistry; the other, the precise study of the "association of ideas." Mill saw that there are certain basic similarities between the psychological laws of association and the mechanical laws recognized by physical science. It is not an accident that, in the same connection, he hoped for a science of social relations—what we should today call social science—in which the study of character, of economics, and of history would be so ordered as to throw light on the possibilities of human progress. It must not be supposed that Mill profoundly altered scientific method; rather, he stated clearly just what was involved in scientific method and tried to find just what it could and could not do. It seemed to him that psychology and physical science might both benefit by finding the basic laws of thought which we have to use in understanding the world and ourselves.

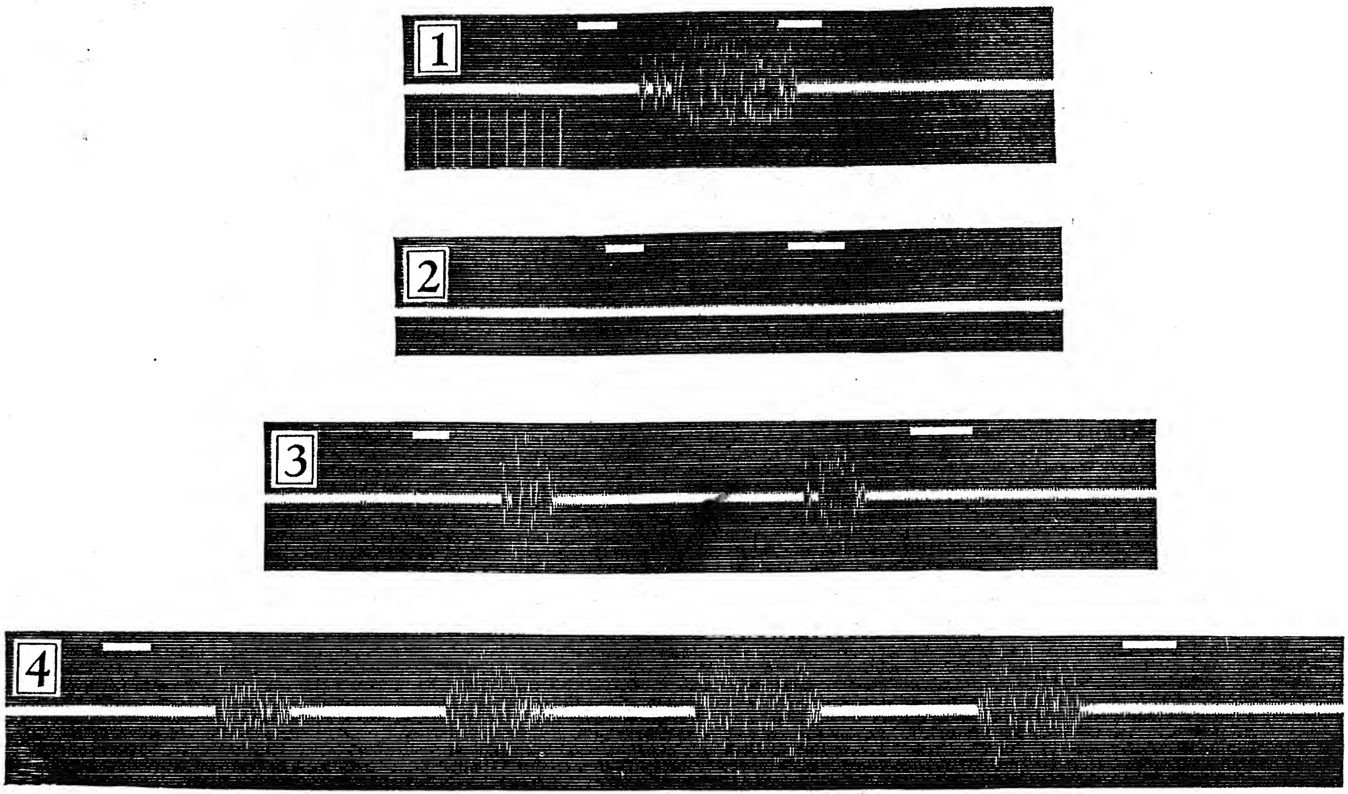

1
2
3
4

FIG. 86.—Relation of muscle activity to mental processes. These are all photographic records of changes in a galvanometer, showing presence or absence of electrical activity in the muscles in which the experimenter has placed electrodes. The continuous white line in the middle of each record indicates a relaxed state, the fine scattered white lines indicate that the muscle is contracting. The short horizontal white lines just to the right of the numerals represent signals to the subject for starting and finishing.

1. The fine vertical lines in this record show activity in the biceps muscle of the right arm when the subject was told to "imagine lifting a 10-lb. weight with the right forearm." 2. This is the control test where lifting the weight with the left forearm was imagined. No activity occurred in the right arm muscles in this case. 3. Here the subject was told, "Imagine hitting a nail twice with a hammer held in your right hand." Each of the two blows shows up distinctly. 4. This record shows muscular activity while imagining the performance of a rhythmical act. From E. Jacobson, *Amer. J. Psychol.*, 1932, vol. 44, p. 683. By courtesy of the editor and the author.

Discussion about "scientific method" has gradually led to a pretty clear recognition of certain empirical steps which are always involved when this method is used, although it will at once be grasped that they are not always used in the *order* indicated below. These steps are: (1) observation; (2) classification of things observed; (3) statement of a tentative explanation or "hypothesis" as to the relation between one class of observations and another class, (4) further observation to see whether the connection stated in the "hypothesis" actually exists.

In some sciences the conditions under which a given class of phenomena appear can be determined by deliberate manipulation or "experiment." In other cases, one has to take nature as he finds her. The former situation is illustrated by physics, the latter by geology and astronomy. The fact that many aspects of geology and astronomy have as good a scientific foundation as anything yet discovered will undoubtedly dispel the illusion that there is some mysterious value in an experiment as such. As Galileo remarked, it is only because we are stupid that we need experiments. On the other hand, since we are stupid, and since nature is complicated, we are usually likely to find the true conditions which determine an event much more easily by a systematic experiment than by things which occur without our intention.

It will be noted that all the steps given above depend upon the interaction of several psychological processes. Observation itself involves selection from our perceptions, and the classification of observations involves the recognition of similarities and differences. The formation of hypotheses often involves a further recognition of similarities In fact, many hypotheses are in the form of suppositions that one object of observation is identical with another, that is, that there are two ways in which the same object may appear to us. This restatement of scientific method, then, serves to show how complicated are all the scientific processes involved in reasoning. This ought to help to get rid of the notion of reason as a power or faculty mysteriously separated in some way from the rest of our capacities.

SUMMARY

Thinking consists of searching for the right answer to a question. The laws of association which apply to memory also apply to thought, but control is of special importance Under the influence of control, trial-and-error activity goes on in search of a solution. New ideas may form gradually or suddenly—usually suddenly. This appearance of new ideas is called insight. Insights are present in the thinking of even very small children. The more complex thought processes depend upon the ability to abstract and generalize, i e, to state the abstract principle in the form of a concept. Concepts require labels, usually in the form of words Children learn gradually to use words and to handle concepts as their environment requires. Thinking depends very largely upon the use of words. It is even possible that thinking depends largely upon the actual use of the speech organs which repeat in miniature internally what would be uttered if we were speaking Thinking, as exemplified in scientific work, consists largely of observing, classifying observations, offering hypotheses, and testing hypotheses.

REFERENCES

Lorimer, F, *The Growth of Reason*, 1929.

Ogden, C. K, and Richards, I A, *The Meaning of Meaning*, 1923.

Piéron, H, *Thought and the Brain*, 1927.

Robinson, J. H., *The Mind in the Making*, 1921

Titchener, E. B, *Lectures on the Elementary Psychology of the Thought-processes*, 1909.

PROBLEMS

1 Give a full account of your solution of some problem within the last few hours

2. Exactly what criticism of a person's thinking are we making if we say that it is "mechanical"? Is it not true that block signals and

similar mechanical devices perform the task of a thinking man, and perform it better?

3 In the discussion of "transfer" we challenged the theory of formal discipline Is there, nevertheless, such a thing as "learning to think"? Analyze the apparent contradiction and state your own solution of the problem

4 How could the "behavioristic" account of thinking in terms of muscular response be given more decisive testing?

5. Do you agree that "all thinking, all mental activity, occurs in the course of adaptation"? (C K Ogden) Can you recall instances in which thinking was not part of an adaptive process?

6. List some of the instances of rationalization in your own behavior within the past two weeks

7. Give four or five instances of distortion of thinking due to misuse of words.

8 Develop an original test or problem for other students to solve. The test must require

 (a) Attentive study of the problem
 (b) Reflection: an effort to recall something relevant and helpful
 (c) Insight getting a possible solution
 (d) Analyzing and reformulating the solution
 (e) Testing and proving the solution.

CHAPTER XVII

IMAGINING, DREAMING, INVENTING

THE process of imagining is one which interested the earliest psychologists. Aristotle suggested, for example, that all the materials we *imagine* are really the same materials we *remember*. He thought that everything in the mind comes in through the senses; it may be elaborated in an infinite variety of ways, but even the most fantastic product of the imagination can be broken down into the materials provided by the senses. It is not well to dogmatize on the point, but it is of interest to study the general dependence of the inner world upon the outer world An instance is a recent study of the uses of color terms in English since the time of Chaucer, showing the immense influence of industrial chemistry during the nineteenth century upon the poetic imagination. Hundreds of hues are known to the poet's imagination today which seldom or never appear in the natural setting of a sunset or a geological formation. The poet has new material with which to work; he can imagine entirely new things because his range of actual experience is so much greater Chaucer had only a few color terms. Modern poetry not only is richer in language through the development of English and its contact with other languages; the modern poet has actually seen more colors than Chaucer could, and he can therefore imagine more. Imagination depends on what has been taken in through the senses You can imagine a purple cow, but not unless you have seen *purple* and *cows*.

Imagination seeks a new product but is not limited to finding just one correct answer to a problem.—Processes by which images—the residues which lag behind after the sensations themselves have died out—are combined and manipulated, are found in general to be those which have been discussed in connection

with memory. As we saw, association may be either free or controlled, and both kinds of association enter into both thinking and imagination. It is not strictly true (as might at first appear) that thinking is controlled and imagination is free. On the contrary, a large part of the most significant work of the imagination is highly controlled Thinking and imagination differ not so much in the actual mental processes as in the kind of product at which each one aims. If it is just *one solution* which is to be found, and this solution can be proved to be the only one which is adequate for a situation, we speak of thinking; whereas if there are a *number of possible solutions*, we speak of imagination. Typically the scientist thinks and the inventor imagines, not because the psychological processes differ so much as because the very fact that there are so many possible solutions of an inventor's problem is the thing that makes us wish to use the word "imagination." In everyday life we are not absolutely consistent about this, however. We sometimes use "thinking," as in playing chess, when *many* solutions are possible, and occasionally use the term "imagination" to describe the solution of a complex problem which has only one answer. And, of course, the inventing of good hypotheses is one of the chief labors of the scientist; this kind of thinking may quite rightly be called imagining It is just as well, then, to realize that our distinctions between imagination and thinking are not hard and fast. But as a rule it is more in the nature of the result than in the actual processes that they are to be distinguished.

A simple way of studying imagination is through the ink-blot test. Cards are presented to the subject, one after the other, each card bearing an irregular figure which has resulted from dropping a splotch of ink upon it. The subject is told that these blots do not represent anything in particular, but may suggest something; he looks at each blot and writes down quickly the first thing the blot suggests. Such tests of imagination as these may serve two purposes, the pure-science purpose of laying bare the general laws of imagination, and the practical purpose of revealing unsuspected aspects of individual minds. The former purpose is well served by the discovery that the simple ink-blot test demonstrates all the

ordinary laws of free and controlled association (contiguity, similarity, contrast; recency, frequency, vividness; mental set, etc) As a test of individual capacities and tendencies, the test gives a "quantitative" view of imagination in terms of the number of elements per minute, as well as qualitative data on the special hobbies or interests of the subject.

The ink-blot test has recently been given much study, and has been adapted for large-scale comparison of individuals. The individual's *richness of imagination* has been shown to be rather closely related to mental growth, as is shown by comparing normal and feeble-minded children of various levels

In the chapter on thought it was noted that a directive tendency gives greater fertility of ideas in certain areas and interferes with the appearance of ideas in other areas The same fact appears in imagination For example, an experimenter gave his subjects the ink-blot test, then repeated it after showing them some picture post cards. After they had seen the post cards the subjects had many new associations. They found it harder to get from the ink-blots ideas which were new or original. This procedure thus interfered with fertility of imagination instead of aiding it. The more specific the suggestion, the more it was found to cramp the imaginative processes, limiting them to the theme which had been suggested.

Trains of words and images constitute the materials of which imaginative patterns usually consist. If attention is given to any short interval of imagining or thinking—say, an interval of two or three seconds—the observer usually reports images. But some observers, even when directly attending to an imaginative pattern which has just completed itself, insist that it came to them as a whole, without any recognizable images. Those who think in vivid images tend, of course, to discount the testimony of those who report that they characteristically think of things without picturing or otherwise "imaging" them. The writer is convinced that he is unable to imagine infinity or nothingness without definite visual symbols: the former is a dark gray cloud, accompanied by

muscular strains which symbolize extension in all directions, the latter is a gray film which is flabby and would exert no resistance if seized. But many observers report that they can think of infinity and nothingness without images, and we have no right to reject their testimony. Nearly all observers report that *words* do play an important part in imagination; and the more complicated the thing which is imagined, the more essential the words are.

We imagine in order to satisfy needs.—Instead of confining ourselves to images and words, which are the chief *contents* of imagination, we shall endeavor to see the *process*, i e, to note *why* we imagine, what *function* our imagination serves. From this point of view, imagination is a mode of *adaptation* arising from tension or want and undergoing the same process of trial-and-error activity that we found in the case of learning. This will mean that the process of imagining, instead of being "influenced by motives," has become part and parcel of the life of motivation. To say that imagination or thought is "influenced" by our wishes, as is so common in discussing our modern political and economic thinking and planning, is so much of an understatement as to be absurd. It is like saying that a locomotive is "influenced" by steam or that electric lights are "influenced" by the current coming from the power house. We imagine things chiefly because we want them, or fear them, or are excited or interested by them. Imagination is a device for "attaining unattainable goals." From the first appearance of language, the little child's patterns of words reveal wishes; and if his wishes cannot be objectively fulfilled, his spoken fantasy during play, in absent-minded moments, or in falling asleep, reveals the richness of his techniques for wish-fulfillment through imagination. Close attention to such spoken fantasy does much to deepen adult understanding of children That words and images can give direct satisfaction, a satisfaction like that of the events they symbolize, is early discovered by most children, and their use becomes a habit indulged in for its own sake; there are few adults who so completely outgrow this as to have no "castles in Spain." In these cases imagination is *its own reward.* In other cases we

imagine in order to achieve an *objective result* which satisfies us In both cases, imagination expresses our *motives.*

The study of dreams offers an unusual opportunity for the study of imagination.—The rambling, confused kind of dream affords rich materials for the study of relatively free association, probably subject to less control than any waking association exhibits. Other dreams are obviously governed by more definite control, in the form of haunting fears or of wishes. It will be worth while to consider first some of the relatively uncontrolled forms of dream association, and then proceed to those in which elements of control are clearly recognizable.

Many dreams are largely the result of physical stimulation. A sleeper whose nostrils were tickled dreamed of a tar mask being drawn from his face Another whose sleep was disturbed by trumpets dreamed of a procession with pomp and circumstance Many dreams of flying appear to be produced by movements of the limbs, and dreams of being scantily clad arise when we are cold, or the bedclothes slip off, or the temperature is lowered. Klein has recently published a series of experiments of this sort Believing that the earlier students of dreams were right in their emphasis on posture, he brought an army cot into the laboratory and had his subjects lie in various positions in order to see whether dreams reflected the influence of posture. In this experiment he put his subjects into an hypnotic sleep, but there seems no reason to believe that the dreams differed in any fundamental respect from ordinary sleeping dreams. In one case he found that pressure on the foot of the cot caused dreams of falling feet first, whereas pressure on the head of the bed caused a dream of falling head first It was even possible to produce dreams of rolling downhill by pressing the side of the cot One subject told him of a series of falling dreams in which he had fallen feet first; this had occurred in his ordinary night dreams. On inspecting the bed, Klein found that the springs were broken at the foot, causing the subject's feet to be lower than the head. There are usually many changes of posture during the night, any one of which is likely to cause a

dream of falling, flying, running, or the like; it is only necessary to remember that the dream may magnify or elaborate a simple stimulus. The pressure of cold metal against the forehead made some of the subjects dream of cold weather. Having found that the humming of a tuning fork made his subjects dream of airplanes, Klein pressed a bit of cold metal against the forehead at the same time that he sounded a tuning fork. The subject completed the pattern by dreaming that he stood in a snowstorm beside a hangar waiting for an airplane to come down.

It seems possible, too, that dreams of terror may be produced by acceleration of the pulse and partial suffocation due to pressure on the heart or pulling the bedclothes over the face, what would be a more or less uncomfortable or dangerous situation if the person were forced to remain in it while awake might be a direct cause of rather violent fear in the confused mind of a sleeper However, this is probably too simple a picture of what happens Probably through trial and error we have learned what will wake us up when in an uncomfortable position, and the vague consciousness of the dream sees to it that the fright is bad enough to put the whole body on a "war footing," thus automatically waking us. This is a "purposive" theory of the dream, in the same sense that the random trial-and-error activities of any organism which is trying to learn something may become increasingly purposive as the blind alleys are eliminated

Most dreams are lacking in a "critical" attitude. One might say that dreaming is simply imagining when one is asleep, and that all the laws of imagination appear in their usual form, subject merely to the limitations which the lack of critical intelligence imposes (because the brain is not capable of functioning at its best). This may be taken not only in a negative but in a positive sense to explain why in some cases dreams are more brilliant and fertile than waking states Coleridge composed much great poetry when he was wide awake, but he never composed anything greater than *Kubla Khan*, which came in a dream. Just as drugs which are otherwise harmful may remove self-consciousness or inhibitions and let a person give his full powers to a task, so the freedom

from self-criticism which appears so often in the dream may give the poet or inventor a special opportunity. Many inventors give sleep, and in particular the dream, a good deal of credit; we have no right to run counter to direct testimony merely because of our popular prejudice that to be drowsy is equivalent to being stupid. Under special conditions we get our best ideas when we are asleep. This does not, of course, obviate the necessity of critical selection from dream material when one is wide awake.

Dreams are often sequences of images resulting from relatively free association.—These observations relating to association and absence of critical sense may be brought into a unified scheme by suggesting, as did William James, that in dreams the whole brain is not asleep; some parts are asleep, others are awake (cf. page 432). Suppose that a physical stimulus like slight stomach distress or cold air on the face starts off a vague train of associations. Perhaps the fact that most of the brain is asleep will alter the course of associations Suppose the normal free association to air on the face would be something like this: cold, winter, snow, fall, drop, break, brake, train, locomotive, steam. This is, of course, nonsensical, but it would be recognized as a fairly typical "uncontrolled" chain of associations. Suppose now that when one begins with the idea of *cold*, the pathways in the brain which lead in the direction of thinking of *winter* and *ice* and other "normal" associations happen to be blocked up, but that at some earlier time one had seen a marionette performance in which the figures shivered in a paper snowstorm. The cold might lead to the idea of marionette. Now, from the marionette normal associations might ordinarily follow, such as *doll, puppet, string,* and so on. But suppose these connections are all "asleep" at the time. Nevertheless, one has at some time read the story of Pinocchio; this, then, will perhaps be an open pathway. Plenty of ordinary associations with Pinocchio might occur to one, but it may be that when he originally read the story it was Christmas Eve. All the other pathways being closed, Pinocchio may then lead to a "Christmas Eve" reaction We might then have a dream of the following type: Cold, marionette, Pinocchio, Christmas Eve—a more or less inco-

herent series, more incoherent than is usually found when one is awake Pathways being largely blocked up, the lines of association might be like those followed by an automobile in a flood, an endless succession of detours This is, on the whole, a pretty good theory. Of course, the "pathways" in the brain need not be like footpaths; such terms are just *names for dynamic relations* between successive activities (cf. page 205)

The theory has at least one weakness; it does not explain the difference between children's dreams and adults' dreams. It is maintained by Freud that children's dreams are practically always *direct wish-fulfillments.* A little child is skating and is called in at supper time. That night she dreams she goes on skating A child's dream is, according to Freud, a straightforward obvious *continuation of some enjoyable activity.* Freud asks why adult dreams are more confused than children's dreams and why they do not directly *express wishes* as a child's dream does. The theory offered by William James does not really explain the matter; in fact, it cannot since it pays no attention to wishes or to the peculiar characteristics of childhood dreams No one has made a systematic study of children's dreams to see whether they are wish-fulfillments to the extent that Freud believes. Judging by the few reports we have, there seems reason to doubt whether wish-fulfillment is a universal characteristic of dreams at any age. But the data are incomplete.

Even in the rambling kind of dream, we have noted that the dreamer seems to be an incomplete person—parts of his mind are blocked off and fail to participate in the dream. He is, we said, lacking in "critical sense." Whether this is to be explained through brain physiology or not, it is one of the major dynamic facts about dreaming As we pass from the rambling to the organized fear-ridden or wish-fulfilling dream, the same fact appears even more glaringly. Many things happen in a dream which cannot happen in a waking association because in the dream interfering lines of thought are shut off. The daydreamer cannot, as a rule, cut himself off completely from the world which the senses report to him. But the night-dreamer, because the senses report so little and because

the maintenance of continued contact with the world is not demanded, is carried along by trends which in waking life could receive no such exaggerated expression The very vividness and realism of the dream are dependent on the shutting out of all that might contradict its story This fact of the splitting of the personality into two or more systems, one being free from the control of the others, is of such major importance in relation to dreaming and to the whole life of the imagination that we shall have to look at it more closely in the following paragraphs.

If association is the word to describe the *connecting* of various parts of mental life, we need a corresponding word to describe the *breaking down* of wholes into component parts. In some cases we speak of analysis, as we have already done in discussing perception (page 173) Sometimes, however, we speak of *dissociation*. This concept first came into general use in psychology when physicians had to deal with patients whose minds seemed broken up into disordered fragments.

But the mind may be "broken up" in many ways and in perfectly normal persons. Parts of the mind are capable of functioning without the rest. If a man works over a problem in the evening, goes to bed without solving it and wakes up with a clear and definite solution, he is said to have achieved this through "unconscious cerebration." The cerebrum had carried on activities so distinct from those of ordinary life that the waking self remembered nothing of the processes which went on in the sleeping mind. French physicians and psychologists undertook to study such cases experimentally, believing that they found in this concept of dissociation a clue to abnormal failure of recall (cf. page 287). Patients suffering from no brain injury often forget episodes which have been important in their lives. They are peculiarly liable to forgetfulness when emotional experiences are involved After a frustrated love affair, the patient may forget not only the incident, not only the name of the lover, but the entire year in which the painful episode occurred. The war-shocked soldier who has seen a comrade blown to pieces fails to remember not only the comrade

but the whole fortnight during which this occurred. The fact that something has been wrenched loose from the ordinary functioning personality makes the physician search for the lost material *somewhere else.* He tries to explore the "subconscious mind," defined as a mind beneath or out of reach of consciousness, full of episodes which the conscious mind cannot recall He finds, indeed, that persons suffering from gaps in their memories can be greatly helped by special psychological methods Thus, for example, the war-shocked soldier may betray by unconscious movements something of the character of the disturbance, and this may be directly exploited by putting a pencil in his hand and engaging him in conversation about something far removed from his trouble. The hand may flounder about, the pencil being moved so as to trace a few words which give a clue to the trouble although the patient does not know he has written anything. In a surprisingly large number of such cases the words written are enough to show the general character of the forgotten experience. Connected discourse may be written down. The emotional episodes which are the first to express themselves through the writing may prove to be relatively superficial symptomatic responses; on later occasions the writing will tell of more and more deeply hidden impressions of which the patient is unconscious. Another equally suitable device is that of gazing into a crystal ball. After prolonged fixation, a film may form over the surface and the ordinary light reflections no longer appear. In a few moments vivid hallucinations begin to form themselves upon the film. These may portray painful reminiscences which had been shut out from consciousness. A third device is that of listening to a conch shell. The dull roaring sound which everyone hears is gradually replaced by articulate sounds which in time become hallucinatory spoken words. (From this it is not far to the ordinary auditory hallucinations which come from the same "subconscious," as warnings or reproofs to those who are troubled about real or imaginary sins or enemies or omens of destruction.) In all these cases the activity is carried out by a part of the organism which is not the same as the *conscious* person.

There are as many devices for "tapping the subconscious" as one wishes to ask for. It so happens that automatic writing (with its specialized forms—planchette writing and the ouija board) has become particularly popular because many people with slight dissociations work more rapidly in this way than in any other, and the messages have a more or less obvious meaning to those who are interested in the thing as a game. The fact that the messages conform in general to the characteristics of the writer, and that they often take on spiritualistic form, does not decrease the psychological interest in the contents of the message as a possible clue to forgotten or repressed experiences.

The fact that some mental and physical functions can go on partly independent of the rest of the organism is really too commonplace to require proof. Almost every absent-minded act, almost every automatic habit, like shifts in posture when riding a bicycle or pulling a key out of the pocket as one approaches a door, indicates what is meant. When larger and larger groups of functions get separated from the introspective consciousness, the problem begins to attract more interest, and attempts are made at a systematic interpretation. The term "dissociation" is not descriptive, much less explanatory. It is simply a *name* for the fact that the degree of integration of total behavior is at times less complete than usual. Some experimenters believe that under special conditions dissociated functions may remain *conscious* though severed from ordinary *personal consciousness*, for example, that at one and the same time there may be a *conscious* following of a lecture and a *subconscious* fumbling with one's keys. Morton Prince described experiments which seemed to him to prove that subconscious activities were not just *automatic* physical activities, but were similar to ordinary conscious activities. For example, when a patient was asked to describe the appearance of a man she had seen, she could give only a vague general account Nevertheless, in a *profoundly relaxed* state, she could give a detailed and accurate account. Prince's assumption was that a *part* of the mind had observed and recorded impressions which were not available to recall by the ordinary, narrow, conscious self. Nevertheless, the very fact that

they could be recalled in an altered, relaxed state, proved that they had been present in an *independent consciousness*, outside of the main consciousness, all the time. This separate consciousness is not ordinarily known to us, and is therefore called "subconscious."

Others have believed that such experiments as these are inconclusive because the impression might have been made on the retina and on the brain without involving *any consciousness whatever*. The impressions may have been simply physiological; and when words requesting a report were later addressed to the subject, they touched off reactions of a verbal sort which pointed only to the presence of these physiological dispositions, not to the reality of a subconscious mind This question about the subconscious is still unsettled. It really has nothing whatever to do with the main body of clear-cut facts about dissociation which we need and constantly use in our study of dreams, invention, etc.

Dissociation probably exists in at least three forms: (1) Part of the mind is incapacitated (through sleep, drugs, etc.), but the rest continues at work, as in the case of dreams and delirium. (2) There are physiological activities going on in the central nervous system which are more or less similar to those which occur in connection with consciousness, yet under special conditions they may be unaccompanied by any kind of consciousness on which the person can report This is the case in many absent-minded activities (3) There are instances in which prolonged periods of unconsciousness are followed by prompt and effective behavior which certainly could not have been carried out in the interval *before* unconsciousness commenced. We refer now not to solutions of problems in dreams but to solutions which appear to have come in states of *absolute* unconsciousness Thus we have a report of a complete geometrical solution of a difficult mathematical problem which appeared as a full visual hallucination on the wall at the moment when the mathematician opened his eyes. His efforts before going to sleep had been in the direction of an algebraic solution, and he had not dreamed about the problem as far as he knew, so that the geometrical solution seemed to him completely new. We lack good *experimental* data on such cases It is quite likely, as many have

suggested, that the right beginnings had been made toward such a solution even before the sleeper lost consciousness; that during the sleeping interval, wrong beginnings, confused and interfering tendencies in the brain, died out or became completely inhibited, and that in the moment of awakening, the good beginnings, free from the previous interferences, rushed through to a solution This would constitute a shift in perceptual pattern similar to those already described (page 255), and would differ from them only in that the shift from a faulty pattern to a correct one seemed dependent upon an interval of quiet in which the faulty pattern could drop out. Another important fact in this connection is that one often awakes with a new mental set A *new attitude* or a *new mood* removes the faulty outlook on the problem and permits a fresh approach.

Reorganization in the perceptual field may occur during or immediately after sleeping states. This reorganization is quite similar to that found in waking life. We may reorganize what is in the mind at a given time, but the material which is reorganized may include far more than can ever be held in consciousness at any one moment, our whole viewpoint may suddenly change. In this reorganization we *use* far more material than is available to consciousness at any given moment. In this respect, imaginative processes in dreams and at the moment of awakening are merely vivid illustrations of a principle very evident in waking life, not only in imagination but in other activities. A man's skill in golf is dependent on a great deal which does not directly enter consciousness. The use of non-conscious material in these cases of skilled action or judgment is in no way different from the use of non-conscious material in imagination, though the dramatic character of the result may, at first sight, make it seem so.

Dissociation frees part of the mind for imaginative effort.—An illustration will serve as summary. A scholar at work on the deciphering of an ancient Assyrian inscription had struggled fruitlessly to put together some shattered fragments so that the inscription would make sense. He had no success. That night in a dream an Assyrian high priest came to him, showed how the

fragments should be put together and how the message should read. Upon awakening he tried the new combination, and found the text clear and acceptable; subsequent research showed that the solution was correct The dream had carried on the daytime purpose and reorganized the data; it dramatized the situation; but the drama is the fulfillment of the dreamer's need The scholar had all the necessary *data*, but the perceptual reorganization was effected in an unusual mental state. The fact that the mind was dissociated made the concentration on the *essentials* of the problem easier and assisted in the creative work.

We have approached the problem of creative imagination through the roundabout route of the dream and kindred "dissociated" processes, because these help to make plain two immensely important facts about the nature of creative functions. First, they reveal the way in which large quantities of previous experience may be organized and used to meet an urgent need, second, they show how such organization depends upon selection. Not only is the pushing aside of irrelevant material necessary to the attainment of the goal, but in many cases the preoccupation with a given material necessarily involves the limiting of the field of operations; this limitation is the basis of most dissociation. Remembering what has been said about the unity of attention (page 215), we can easily see why concentration upon a task involves the ignoring of other interests. The more urgent the need, or the more difficult the task of creative reorganization, the more rigorously must the creative worker *shut out* those interests which belong to the relaxed, easy-going part of his make-up Through such exclusion and through the bending of every effort toward the achievement of his purpose, he is able in rare moments to mobilize a range and depth of experience which is denied in less eager moods; or sometimes, having struggled fruitlessly and abandoned the task for a while, he is surprised the following day to find the desired pattern come "sauntering in," as Emerson said, as if it had never been called for

There have been many studies of the processes of creative

imagination and invention. A remarkable similarity in the basic psychological facts is found, whether one is concerned with the fantastic visions of an opium-eater or with the details of the inventing of an automatic soldering machine. Investigations have, as a rule, proceeded by the following methods: (1) biographical study of men of genius; (2) questionnaires and interviews gathering data on contemporary artists, literary men, scientists, and inventors, (3) laboratory studies in which complicated tasks requiring imagination are to be carried through.

Invention usually involves (1) recognition of a need, (2) reflection on ways of satisfying the need, (3) a glimpse of a solution, (4) a period of hammering out.—The processes carried out in invention are: *First,* a recognition of a need. This may be the need for an instrument to do a certain kind of work, or the need for a chord or color that will produce a certain feeling, etc. *Second,* reflection on this need and on the possible ways in which it might be satisfied. This process is laborious in the case of a person who is dealing with a particular subject matter for the first time *Third,* a glimpse of a solution. A new *pattern* is formed, usually more complex than the mere establishment of a new relation between one element and another. (The analogy of a flash of lightning is really not so far-fetched; photographs of lightning show that even this supposedly simple occurrence presents a complicated pattern.) These phenomena of sudden "illumination" are apparently not very different from what we all experience when we try to "make out" something at a distance in the twilight. We can see it now as one thing, now as another; but it is with a sudden and definite sense of satisfaction that we at last "grasp" what the thing is. Of course, this sense of satisfaction may come when the thing is not correctly grasped at all; in fact, the sudden solution is far from being infallibly correct. The biographies of geniuses are full of instances of satisfying solutions which had to be discarded the next day. Nevertheless, it is of the essence of the flash of insight that it should really come suddenly. Whether it will be recognized as erroneous or not will, of course, depend upon many circumstances *Fourth,*

a period of hammering out, in which this sudden insight, whether it is a plot for a drama or a design for a ticket punch, is perfected, and all sorts of adjustments are contrived to make the thing workable.

Practically always the steps are taken in the order given; they never would be taken without the original sense of need and the willingness to labor toward the satisfaction of it. The musician who does not care whether a chord is resolved, the physician who does not care whether the proper diagnosis is made, may acquire vast quantities of information which would really help toward a solution, but he actually accomplishes little. For the most part, invention is governed by the need, the interest, which, as we have seen, lies behind practically all trial-and-error activity. Five-year-old Mozart hears certain sounds and loves them. Because he loves them and their combinations and wants to make new ones, he applies himself to music. Probably a large part of his creativeness is a matter of delight in tone.

Even a genius of Mozart's brilliance, however, must work by trial and error until he has learned how to handle certain combinations of tone. Works of art, or practical inventions, do not really come as "bolts from the blue" to those who have never thought of or studied a given topic Very simple inventions might at one time have come this way; but even the celebrated case of James Watt inventing the steam engine after observing his mother's teakettle, breaks down when one discovers that other steam engines were already in use and that Watt studied the problem for years before he invented anything. One of the most spectacular strokes of genius in the nineteenth century, Hamilton's discovery of quaternions (which, as he has told us, came to him in a few seconds), is known to have been based upon twenty years of study of the very problem which he suddenly solved. In Rossman's recent book, *The Psychology of the Inventor,* not a single case is reported of a valuable invention by a person who was not well acquainted with the field of his contribution.

Moreover, one *learns* to invent, that is, to combine ideas in fruitful ways within a given field. This is almost like the forma-

tion of higher units discussed in relation to telegraphy and typewriting (page 240). Some of the inventors whose work is described by Rossman have hundreds or even thousands of inventions to their credit.

"Illumination" depends on reorganization.—The heart of the problem is the nature of "illumination." This act of gaining sudden insight is often described in terms of a reorganization in the *perceptual* field. Often, however, as we saw in the case of dreams, it is the material held in the imagination, rather than the material directly perceived, which is newly organized The visual pattern in the mind's eye of the poet or painter may undergo transformation as rapid and profound as any which appears to the external gaze. Indeed, if we may believe their own words, the material of their imagination is often amazingly flexible. Still more reorganization of material, however, enters into the workshop of one with great creative powers Most of the content of his vision comes not from what lies ready in the form of images, but from great storehouses of pictures or sounds or words, the origin of which he is often at a loss to describe Using the term "subconscious" to describe only what lies outside of consciousness, we may safely say that the range of the subconscious materials used by creative artists and thinkers of all sorts is usually far greater than that of conscious materials.

In some instances it is possible to gain access to the storehouse of the poet's mind and find where these variegated materials come from. It so happens that Coleridge's *Kubla Khan*, perhaps the most original and unplanned poetic structure in the English language, has been studied from the point of view of thorough biographical and historical scholarship, with the result that twenty-five years of Coleridge's reading and reflection are shown to be condensed and reworked in these eighty lines. The travels, the books, the conversations which had made up Coleridge's life are there, and the slight transformations to which they have been subjected are easily understood. The fact that this came to Coleridge *in a dream* is of special interest; but that it came to *Coleridge*,

not to Darwin or Beethoven or even Shelley, is the point of departure for a psychological study.

Biographical study of creative imagination affords an avenue of approach as suggestive perhaps as is the experimental study of the dream. These inquiries throw light only on the storehouse from which the treasures are drawn, not upon the processes by which they are selected in a new creation. Such processes are almost infinitely various, depending upon mood, temperament, and the chance association of the day and hour—depending, indeed, upon *all* the factors upon which free and controlled associations themselves depend.

The reorganization is guided by the mental set which has been aroused by the need.—Emotional factors play a prominent part in all creative work. Overemphasis upon laws of association might lead us to overlook the important factor determining all directing tendency, the *mood* on which the process of selection is based. In a composition like the "Pathetic Symphony" of Tschaikowsky, a mood is obviously central to the entire work. Whether or not there are innate emotional responses to the materials of art, the artist has for years associated particular tones, colors, forms, words, and rhythms with particular emotions; other words, rhythms, etc., are inappropriate and have been forced out as irrelevant and disturbing. By virtue of a subtle responsiveness to those elements which are harmonious to the mood, a wealth of pertinent material has been assembled year after year; and this, in a moment of intense feeling, takes shape as an expression of the mood. At least half of the creative work of the artist is dependent on *emotional responsiveness* to what he sees and hears, for in this way are formed the patterns of association which make up the storehouse upon which he draws. There is reason to doubt whether creativeness of a high order exists except where marked sensitiveness to a special kind of material has existed for a long time. And in certain *kinds* of mood certain *kinds* of creative work are possible; the mood acts as a favorable mental set to bring back the material that was present when the mood was experienced before. The work of Edgar Allan Poe is an outstanding illustration

of this. But the fact is commonplace; it has been found in laboratory tasks in which melodies made up by different subjects at different times reflect the emotions and dispositions of the particular time.

The need for creative activity may be felt so strongly as to be an impelling force.—Sometimes creative insights come best in a dream, in a drowsy state, in delirium, in a hashish or opium vision; but in the long run most of the great insights come in normal waking states Yet when we say "normal" state it must be remembered that it is often a *tense* state, a state of concentrated direction toward a goal. When the artist or inventor is learning to create he may have more difficulty in sustaining his concentrated attention, but when the task of creating has been mastered he may be literally overwhelmed by the new idea. Just as everyday people may be dominated against their will by a tune which runs through the head, so the great composer is sometimes actually *driven* by impulses and ideas over which he has no conscious control Nietzsche wrote *Zarathustra* because it *came* to him Blake wrote down what the vision-forms told him to write. The compelling thoughts are the results of a lifelong want, a yearning which the artist has learned how to satisfy; yet the material with which he works organizes itself and comes upon him at times with a force and novelty which astonishes him.

In one instance a composer told in some detail how he learned to compose;[1] every step in the narrative is important for a theory of creative imagination. As a little boy he heard music only rarely; but he loved it intensely, and, since he had no instrument, he played the tunes again *mentally*, rehearsed them over and over. The imagery was at first poor and weak, he enriched and intensified it, imagining, for example, the tone of a violin. "No sooner did I begin this self-training than I had at times curious experiences of having glorious sounds leap unexpectedly into my mind, original melodies and complete harmonies such as I could not conjure forth at will " At first he could not control these experiences, but he learned how to shape and direct them, to turn the flow in one

[1] Reported by L. M Terman, *Amer. J. Psychol*, 1926, vol 37, pp. 233-6.

direction or another Voluntary control developed. But it never crowded out the influence of *mood*. "The musical ideas as they run through my mind seem to be an exact mirror of my emotions of the moment, and of moments which I recall through memory" The process of training which began humbly resulted in a richness of internal harmony that could not be rendered by any musical instrument, for no instrument exists which is sufficiently free from mechanical flaws to play what the composer's mind demands of it. Here are a *need*, a *sensitiveness* to one kind of stimulus; long *practice*; sudden *reorganization*; finally, voluntary *control* of imaginative material drawn from a storehouse far greater than any immediate stimulus could supply.

SUMMARY

While thinking looks for the right answer to a question, imagination looks for any new product which will satisfy a need. The need may be satisfied directly, but usually control must be present; and controlled association leads by a devious course to the end product which satisfies the need. Dreams are usually relatively simple forms of imagination in which control is slight This is possible because dissociation separates most of our waking activities from the activities which fulfill the need; imagination is more free to fulfill needs because the incongruous or absurd is not so troublesome. Dissociation is also a clue to invention. Invention requires the presence of a need and of trial-and-error activity Usually a glimpse of a solution comes suddenly. The solution must be reworked in order to be perfectly satisfactory. Inventing or any other kind of creative work may become a habit so that insights or illuminations come more frequently and may bear a closer relation to the known habits of a person.

REFERENCES

Downey, J, *Creative Imagination*, 1929
Kimmins, C. W., *Children's Dreams*, 1920

Ribot, T., *Essay on the Creative Imagination*, 1906
Rossman, J., *The Psychology of the Inventor*, 1931
Varendonck, J., *The Psychology of Daydreams*, 1921.

PROBLEMS

1. It is often said that reverie or daydreaming may have a definite use aside from immediate enjoyment, in that it may uncover associative connections which a person is unable to reach when he is dominated by an everyday routine *mental set* Can you give, from your experience, an example of such a process?
2. A possibly maladaptive type of reverie is that which serves as an escape from the necessary realities of life, the daydreamer turns inward, and seeks a refuge in his own imaginings Can you cite any instance in which you have reacted in this manner? Was there any harm in it? If so, of what sort?
3. Have a friend, serving as experimenter, suggest to you some occasion, fairly recent in your experience (such as a play or a dance), review this occasion, silently, by a kind of free recall, letting the thoughts come in any order After a certain interval, to be determined by the experimenter (20, 30, or 40 seconds), count up in retrospection the number of images or ideas which occurred during the period, repeated a number of times, with various sorts of material, this will give you some rough indication of the speed of free association
4. Make a systematic analysis of some bit of creative thinking that you have done during the last week or so, some plan you worked out. Show how the psychological principles discussed in the chapter operate in this case. Were there any obstacles or inefficiencies in your planning which would have been removed by applying psychological principles? What important aspects of such a process have failed to receive adequate treatment here?
5. Compare and contrast an apparently "incoherent" and a "wish-fulfilling" dream.

CHAPTER XVIII

INTELLIGENCE TESTS

DIFFERENCES between individuals used to be considered unimportant by those whose conception of psychology meant simply the discovery of general principles. But with the acceptance of the theory of evolution, the study of individual differences between human beings became of central interest. It became important to study individual variations among the descendants of common ancestors, because it was in the very fact of this variation that we might understand the survival of some individuals and the destruction of others. Galton, the cousin of Darwin and the first of all the evolutionists to turn the theory to account in psychology, saw the significance of the problem of individual differences in human beings. He devised a great variety of methods of counting and measuring personal traits, both physical and mental. He explored the minds of artists, mathematicians, and inventors in terms of their types of imagery and their modes of intellectual work, and constructed his own experimental devices for the study of association. Individual differences were emphasized.

Intelligence tests were devised by Binet to measure degrees of brightness in children.—Though it is right to regard Galton the founder of *mental tests*, the credit for preparing and making practical a series of tests for the measurement of intelligence should go to Alfred Binet. Having been at work for years on the problem of intelligence tests, he was appointed a member of a committee to devise tests to segregate the stupid from the lazy among those children who were unable to do the work of the French elementary schools. In collaboration with his friend, T. Simon, he published in 1905 a set of tests for young children, the tests ranged from simple tasks, like pointing to the

nose, to complex ones like giving definitions of abstract terms. The authors were uncertain as to the true degree of difficulty which each test presented. Within three years, however, further work had made it possible to tell at about what age the average child could solve each of the tests which had been published in 1905. The older tests, together with many new ones, were then grouped according to the characteristic age at which they were

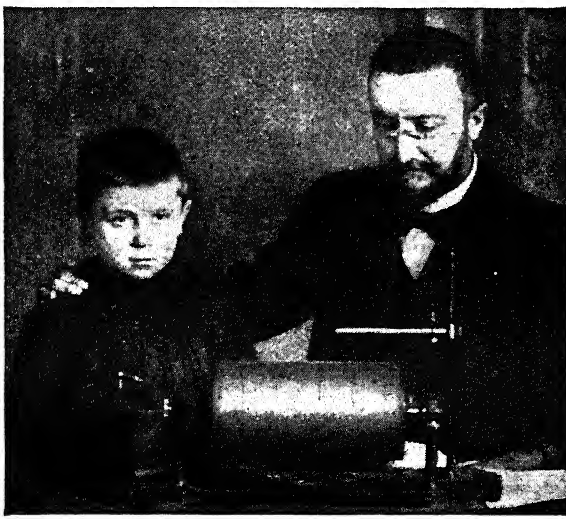


FIG. 87.—Alfred Binet. From J. L. de Bancels, *Année psychol.*, 1911, vol. 18, p. 15. By courtesy of the editor.

passed, or what is termed the "mental age." One more revision of the tests was undertaken by Binet in 1911. The tests were revised at Stanford University in 1916, and another revision has been under way at Stanford for several years, the results of which are soon to be available. These steps of history are interesting in showing the tentative character of the materials included in intelligence tests and the way in which the makers of tests gladly alter or withdraw the tentative offerings of previous years.

The guiding idea of Binet's work was to choose and standardize tests which measured the individual's innate capacities as contrasted with the capacities which depended chiefly upon experience.

In particular, Binet tried to exclude material which was too much affected by school training. He tried to obtain indices of general ability as reflected in the ability to comprehend directions, to maintain a mental set, and to evaluate one's own work ("auto-criticism"). Some tests more or less like those used in school work are, however, found in the Binet scale. Discussion of the importance of environmental influences in intelligence test results may well be postponed until the actual task confronting the tester and the child has been more fully described.

The typical procedure in giving the Stanford-Binet tests is this: A child comes into the room in which the tester sits at a table, equipped with a scoring-blank and a few simple bits of apparatus. The child is first asked a number of questions which he can answer without hesitation. It is the tester's business to put the child at ease and to make the whole setting a natural one, in which an easy-going, matter-of-fact approach to the tasks will be achieved. The tester, who knows the child's age and a little about his personal history from the reports which have been sent in, can guess roughly at what point in the tests to begin. If a child is eight years old but apparently a little dull, the examiner may select six years as a probable "basal age," the level at which all tests will be successfully completed. The child may prove capable of passing these, and also one or more of the seven-year tests; he may, in fact, be capable of passing several tests at higher levels The examiner gives all the tests at each age level, progressing upwards until all the tests at a given age are failures. A reasonable amount of "scatter" is to be expected. A child may pass all of the six-year tests, two of the seven-year tests, and one each at the eight- and nine-year levels. In general, the amount of scatter from the lowest to the highest level is not more than two or three years The definitely bright child of ten does not often fail on any of the tests below ten, but if he passes any of the "superior adult" tests, we are surprised. The feeble-minded boy of twelve who does all the six-year tests successfully, but who fails half of the seven-year tests, will surprise us if he does any of the ten-year tests successfully. In a rough, general way, there is such a

thing as *level* of intelligence The amount of scatter is affected by the presence of strong emotion or distraction, but it is also often significant as a clue to marked special abilities or disabilities.

The intelligence quotient is the mental age divided by the chronological age.—To obtain the intelligence quotient, the child's total score (the mental age) is divided by the score of an average child of his age. Thus the six-year-old child who is able to score only as high as an *average five-year-old* has an intelligence quotient of five-sixths, or .83. In the same way, a child of four who can already pass the six-year-old tests has an I.Q of 1 50 (the decimal point is usually omitted) The I.Q measures the *rate* of intellectual growth, and we can predict fairly well from year to year what the mental age will be for each chronological age A six-year-old with a mental age of five can be expected to have a mental age of about ten when he is twelve years old. Since mental age as a measure of giftedness means nothing except in relation to chronological age, the I.Q. or measure of rate of mental growth is indispensable.

The tests used in the first, second, and third Binet scales are illustrated, to show both the kinds of materials Binet thought useful and the freedom with which he experimented in withdrawing or adding tests, or transferring tests to different age levels.

1905 Scale

Test No.

6. The execution of simple orders and the imitation of gestures The orders are mostly such as might be understood from the accompanying gestures alone
7. Verbal knowledge of objects The child is to touch his head, nose, ear, etc., and also to hand the experimenter on command a particular one of three well-known objects. cup, key, string.
8. Knowledge of objects in a picture as shown by finding them and pointing them out when they are called by name.

1908 Scale

Age 3 years

1 Points to nose, eyes, mouth.
2. Repeats sentences of six syllables.

3. Repeats two digits.
4. Enumerates objects in a picture.
5 Gives family name.

Age 6 years

1. Knows right and left as shown by indicating right hand and left ear.
2. Repeats sentence of sixteen syllables.
3. Chooses the prettier in each of three pairs of faces.
4. Defines familiar objects in terms of use.
5. Executes a triple order.
6. Knows age
7. Knows morning and afternoon.

Age 7 years

1. Tells what is missing in unfinished pictures.
2. Knows number of fingers on each hand and on both hands without counting them.
3 Copies "The little Paul" with pen and ink.
4. Copies a diamond, using pen and ink.
5 Repeats five digits.
6 Describes pictures as scenes.
7. Counts thirteen pennies
8. Knows names of four common coins.

1911 Scale	Compared with 1908 Scale
Age 6 years	
1. Distinguishes between morning and afternoon.	No change
2. Defines familiar objects in terms of use.	No change
3. Copies a diamond	7-year group
4 Counts thirteen *sous* (pennies in American translations)	7-year group
5. Distinguishes between ugly and pretty faces.	No change
Age 7 years	
1. Shows right hand and left ear.	6-year group
2 Describes pictures.	No change
3. Executes three commissions given simultaneously	6-year group
4. Counts the value of six *sous* (stamps used in America), three of which are "grands sous," each worth two "petits sous"	8-year group
5. Names four colors—red, green, blue, yellow.	8-year group

The Stanford revision puts the distinction between right and left at the six-year level, and it includes also at this level the finding of omissions in pictures, the counting of thirteen pennies, and the repetition of sixteen to eighteen syllables; the seven-year tests include knowing the number of fingers (as in the 1908 scale), the description of pictures, the repeating of five digits, and the recognition of differences between common materials which the experimenter names, such as wood and glass. In the Stanford revision the procedure which examiners must follow is standardized in great detail, and the method of scoring the tests is fully defined rather than left to the examiner's favorable or unfavorable impression. It is not an uncommon experience for psychologists and advanced students of psychology to find that a response given by a child is hard for them to classify, whereas the professional clinical psychologist is able to tell instantly how the response ought to be scored and *why*, in the light of the knowledge of the manual of scoring and long experience in giving the test. Competent testers working independently rarely differ much in results obtained with a given child Part of the superiority of the Stanford tests consists in the fact that about a thousand individuals were used as a basis for judgment as to the level at which each test should be placed (about sixty for each age from three to sixteen, sixteen being adult; there are also "superior adult" tests).

The tests are scored in terms of months of credit. If there are six tests for a given level, such as the seven-year level, each represents two months of mental age. The child who is six years—that is, seventy-two months—old is of average mentality if his total score is seventy-two months. The following figure compares the tests of two children 72 months old, and with a *mental* age of seventy-two months, one of whom shows relatively even performance, and the other of whom shows a good deal of *scatter* from low to high ability as one compares his performance on different items. The shaded portion indicates tests successfully passed. The total months' credit is the same, though earned in two very different ways. In each of these cases, the intelligence quotient—the mental age divided by the chronological age—is

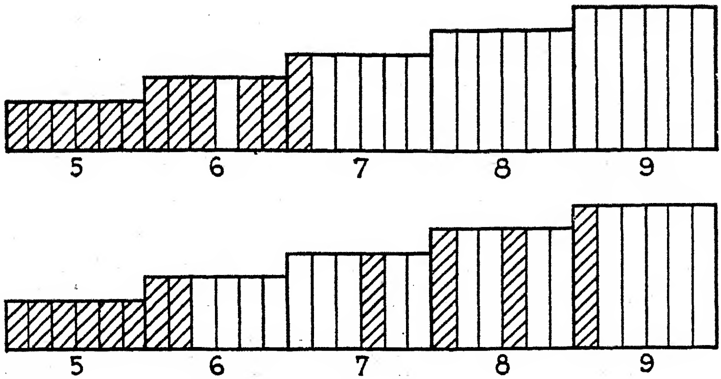


FIG. 88a.—Performance of two children on the Stanford-Binet intelligence test. These children have achieved the same mental age scores, but have given quite different performances. The child in the upper figure passed all of the tests at the five-year level, was credited with ten more months for having passed five tests at the six-year level, and two months more for one test at the seven-year level. Total was 72 months mental age. The second child also succeeded on all of the tests at the five-year level but gained the additional twelve months' credit in more scattered fashion, passing two tests at the six-year level, one at the seven, two at the eight, and one more at the nine. In this test, at these levels, every test passed adds two months' credit. The two children succeed on different tests, yet are awarded the same final score.

$\frac{72}{72}$, or 1.00. If, however, either of these children had passed an additional eight-year test, or any additional test standing above the six-year level, he would have received an extra two months' credit for it. The following is a typical performance of one bright six-year-old child (six years and no months):

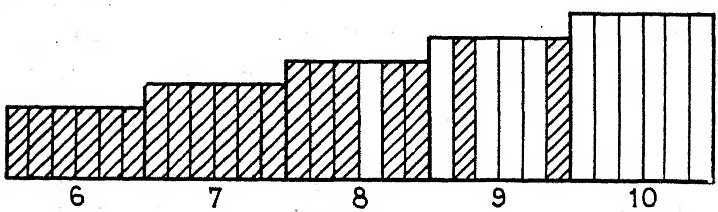


FIG. 88b.—Diagram of the successes of a bright six-year-old child on the Stanford-Binet. Passing all the tests at the seven-year level makes that the basal mental age. Ten additional months are credited for passing the five tests at the eight-year level, and four months more because of the two tests passed at the nine-year level. Eighty-four months (the basal age, seven years) plus the additional fourteen months result in ninety-eight months, which is the mental age assigned. This six-year-old child has a mental development apparently equivalent to that of a child of eight years two months.

The child has not only passed all the tests at the six- and seven-year level, he has passed five eight-year tests and two nine-year tests. The result is a mental age of 98 months divided by 72 months (the chronological age), or an I Q. of 136. One value of comparing a variety of cases lies in noting what different kinds of success and failure in a test will yield the same I Q The I Q is a statement of the *sum total* of capacity in the test, as compared with the number of months lived. It does not give qualitative distinctions between those who are good at one kind of task and those good at another kind of task included in the test. The I.Q itself does not even tell whether the individual is progressing evenly all along the line or whether his achievement is a compound of high and low, competence and incompetence. Moreover, the I Q is but one way of gauging a person's general ability. It is like a line in a portrait, a distinct and significant line, but not a complete picture. It is probably more significant than any other brief, compact item of information about a person's intellectual ability; but, as Dr. Healy has remarked, we should not expect too much in the way of information about a person from the mere knowledge that a certain score has been won on a specific test performance.

Large numbers of people may be tested at once by means of "group tests."—The Stanford-Binet is an *individual test*, since the examiner gives the test to one person at a time. There are several other individual tests which have been well standardized and are in general use. In addition to these, there are *group tests* which are so devised that one examiner can administer the test to many persons at once These are given to school groups as an aid in getting a rough idea of the best placement of children in the grades, and sometimes to adults, as in the case of the *Alpha* test used with army recruits. For purposes of rough classification group tests are adequate in many cases, but there are always individual cases which for one reason or other call for later examination with an individual test. Some of the group tests are "self-administering"; the directions are so clearly indicated that any literate person can go ahead without instruction from the examiner.

Thus the number that can be tested at once is very large. Group tests usually emphasize (1) vocabulary; (2) ability to follow directions (such as "cross out the fourth word in the third line unless it begins with a j; if it begins with a j draw a circle around the last word in the last line"); (3) completion tests ("The ——— smelled the cheese but was too ——— to put his head into the ———," or "Democracy is no ——— than absolute ——— if the condition of the citizens remains equally ———"); (4) "analogies" tests ("Man is to woman as boy is to ———," "Cat is to animal as pine is to ———"); (5) arithmetical problems; etc.

Most of the tests so far described are in large part measures of ability to grasp meanings of words and to respond verbally. It is possible that some other system of symbols—even a gesture language much more abstract than that used by the deaf and dumb—might draw upon the same mental processes which are involved in these verbal tests, but we have no real proof that this is so. It is, therefore, dangerous to assume that tests of this sort are measures of the ability to "think conceptually." It will be better to describe them simply as verbal tests. All the various sorts of tests in which words are to be grasped or combined give rather similar results Even a sheer vocabulary test (in terms of the ability to give a rough definition of meanings of words) gives results which seem to agree well with the average of a great variety of verbal tests. And completion tests, as described above, constitute one of the best kinds of material for inclusion in intelligence tests

Performance tests measure capacity to do things rather than to understand and use words.—It is useful to supplement these verbal tests by tests in which other sorts of mental skill are involved. *Performance tests* usually test the perception and manipulation of objects. The simplest of these involve only the recognition of shapes and the bringing of shapes into relation, for example, the putting of a circular block into a circular hole This is more than a test of perception, since it also involves cor-

rect motor response. Tests of this sort sometimes use the simplest relations in which size and shape are involved, but most performance tests also present more complex relations in which the meaning of each part is grasped. For example, the "ship test" involves the ability not merely to fill up an enclosed space with picture blocks but also to build a meaningful pattern. There may be no defect in a child's simple spatial perception of block-forms nor in his motor skill, but he may fail to grasp the notion of the ship as a ship In the same general category belongs the "manikin test," the pieces representing head, limbs, and body being brought into relation and the performance scored in terms of ability to make a man's figure. Most of the performance tests are of this sort

One of the most complex of the function-and-form perception tests makes use of a number of holes cut in a large colored picture board showing a lively scene Colored blocks, each with a picture of an object, are given to the child From among these he is to find the few which will fill the holes so as to complete the picture appropriately

Mental growth is in some ways well shown by the child's ability to represent what he sees. The child's capacity to represent is tested through study of his drawing, clay-modeling, and use of blocks. In the first stage of work with all these materials, he is dominated not so much by an artistic impulse as by the struggle to *make* something. Later, at three or four years of age, there is a definite attempt to represent what he has observed He does not copy, he cannot analyze well enough to do so (cf. page 178) Apparently the "lumps" of experience he has learned to detach from the blur of the world around him are reproduced as lumps, but his analysis is incomplete The drawing of a thing which one has never previously seen in quite the *same form* necessitates a degree of analysis which for the child is unattainable. The reader has probably noted such things as this: a child who can make out an airplane in the sky a mile away fails to see an adult hiding behind a chimney, although his hands and face are projecting beyond the edge. The child looking at the chimney

cannot break up and analyze precisely what he sees From experiments on the perception of form it seems reasonably clear that the child's early growth in the representative arts is largely a growth in the capacity to break up complex conceptual totals. Such observations have suggested that children's *drawings* may be an important clue to their *mental growth.*

A kind of "performance" test which gives interesting results with children makes use of "a drawing of a man"; this is scored

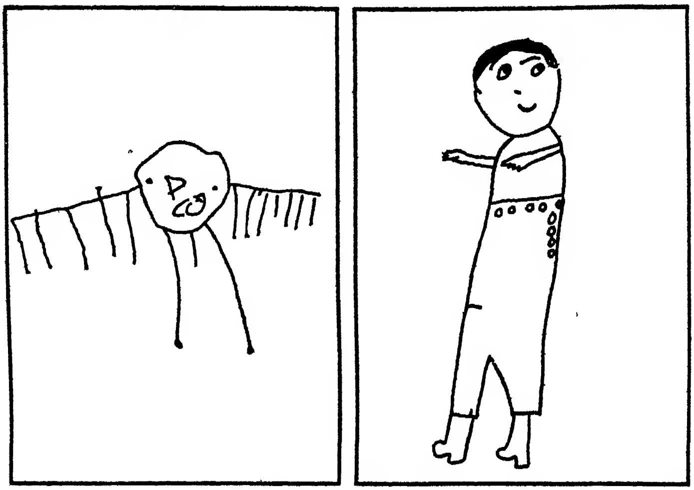


FIG 89—Specimen drawings from the Goodenough man-drawing test of intelligence The first drawing received a total score of 8, credits being awarded for head, legs, arms, eyes, nose, mouth, fingers, chin, and forehead The mental age equivalent is 5 years The second drawing scored a mental age of 9 years and 3 months. From F L Goodenough, *The Measurement of Intelligence by Drawings,* World Book Co, p. 118 and p 140 By courtesy of the publisher and the author

not in terms of artistic success, but in terms of the completeness and adequacy of the representation—whether it contains arms, legs, two eyes, etc.—a certain value being assigned for each element or right relation; cf Fig 89.

Most performance tests emphasize perception of spatial relations One well-known test in which time relations are as important as spatial relations is the Knox Cube Test. Here the

experimenter has before him four blocks in a row. He then takes a fifth block and asks the child to notice what he does with it so as to be able to repeat it. The experimenter begins by tapping once on one of the blocks, handing the experimental block to the subject and making sure that the directions are understood He proceeds in the second test to tap the blocks in order from A to D. The tests get gradually harder; they include such sequences as A, C, B, D, and even such patterns as A, D, B, C, A, B, D. Here the subject must observe closely, retain well, and execute without error what he has observed and retained.

Since these performance tests depend in large part upon the spatial factor, which we should not expect to be closely related to verbal ability, scores for this sort of performance test do not agree very well with scores on standard intelligence tests. They may be used where the use of language tests is impossible; in fact, they are much used with little children. If children are compared over a wide age range—as, for example, from three to eleven years—the verbal and performance tests will agree to some extent because all functions are developing at once and sheer all-round development will produce a rather good agreement (Even height, which at a given age is not appreciably correlated with intelligence, is well correlated with general intelligence *over a wide age range.*) In view of the fact that verbal tests and performance tests agree only moderately well at any given age, it is reasonable to regard the performance tests as a good supplement, helping us to get a better-balanced view of mentality as a whole, but not as a substitute for verbal tests.

The simplest *tests of mechanical ability* require only that the separate parts of a familiar instrument, such as a hammer, be put together. More complex tests involve the ability to do certain things with tools (cf. page 225). Systematic work with such tests shows that it is possible to measure such a thing as mechanical ability; that this ability is not wholly a result of training; that it is not very highly correlated with verbal ability, and that it does predict to some degree vocational aptitudes later shown in the mechanical field. The fact that it is not closely related to

verbal ability does not mean, of course, that verbally dull boys are *more* likely to be good at mechanical things; it means that their chances of being good or poor at mechanical things are neither better nor worse than the chances of a brighter boy in relation to the same tasks But *higher levels of success* in the mechanical sphere depend upon the ability to plan work in advance, to meet business obligations, etc ; in other words, the upper levels of such work are more than fields for the utilization of mere mechanical ability. In some cases intelligence tests and mechanical tests must be used together Thus, in one recent study of mechanical tasks, intelligence tests seem to predict the degree of success in the early stages of learning, and tests of mechanical ability seem to predict the individual's *limits* of achievement.

There are also *group* performance tests In the army *Beta* test the subject's capacity to handle spatial and functional relations was measured. The instructions were given in pantomime before a large group, each individual being shown how to do typical easy tests; the tests then became gradually more difficult.

Intelligence increases with age up to about eighteen or twenty.—Changes in mental age as chronological age increases, computed directly from our intelligence test results, must give us a "straight-line curve" (diagonal, Fig 99, page 414) But if we give the same difficult test to people of many ages, we are more likely to get a curve of mental age like the curves for a specific capacity shown in Fig. 90.

Such curves usually show a rapid gain with gradual slowing down from year to year. These are in a general way like the curves of diminishing returns discussed on page 238 In other words, they show smaller and smaller gains as time passes. This does not, however, prove conclusively that mental growth really slows down, because such curves do not tell us whether a year of *mental* age is really a standard unit like a year of *chronological* age.

The rate of intellectual growth is hard to study because we do not have a real zero point or base line and because we are not

certain as to the true units with which to measure increments of mental growth. If the ordinary tests for age ten are *very much* harder than those for age nine, it is quite likely that the child in passing from the nine-year mental level to the ten-year level has gone a distance greater than that which he covered between eight and nine. Giving one test to people of all ages will not settle the question, for the items of the test vary in difficulty. Since

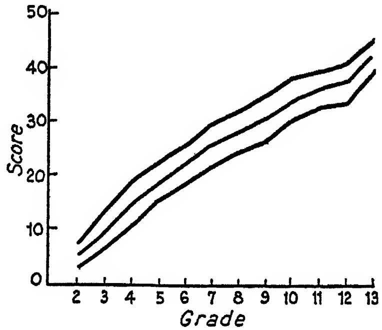


FIG 90—Relation between sentence completion tests and school grades Judged from total scores, the improvement on this test of sentence completion seems very regular as children progress from grade to grade The middle curve represents the median (or middle of the group) scores for each grade The other curves are for the 25 and 75 percentiles, the scores which are "better than the lowest 25 per cent of the group" and "better than the lowest 75 per cent of the group," respectively From F. N Freeman, *Mental Tests,* Houghton Mifflin Co, p. 335, after M R. Trabue, *Completion Test Language Scales,* Columbia Contrib. to Educ, 1916, no 77. By courtesy of the publishers

most people will solve the easy problems and fewer and fewer will solve the problems as they approach the upper limit of difficulty, a score of 70 might be seven-eighths as good as a score of 80, but only half as good as a score of 90, and only three-eighths as good as a score of 92; each unit in a score means more as the units get more difficult. If the actual yearly gain is constant, we should, as we saw, get a straight-line curve; while if there is increasing distance between yearly levels in the middle childhood period, we should have an S-shaped curve like the left-hand one in Fig 91. Until we are sure, first, as to our absolute zero or base line for our mental measurement and, second, as to the real equal-

ity of all the units (such as the equality of the steps between the various mental age levels), we cannot tell the true form of the curve. Note the different curves for different tasks in Fig 91.

We now have reasonably complete data on the growth of intelligence in terms of standard tests through the fourteenth year, since tests can be given to practically all children. But as children drop out of school our sample is less and less complete It would be all very well if those who dropped out were drawn equally

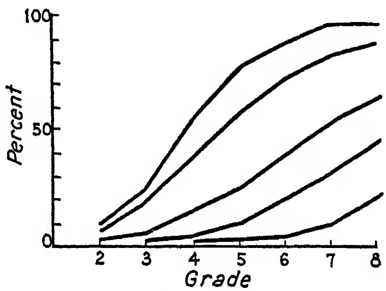


FIG. 91 —Relation between completion of specific sentences *of varying difficulty* and progress in school grades These curves represent the performance of pupils in the different grades on individual sentences of the test used for Fig 90 Instead of the regularly rising curve obtained when all the sentences are lumped together and the total score used, these curves show that for different specific sentences within the test there may be different rates of progress in performance, providing differently formed curves From F N Freeman, *Mental Tests,* Houghton Mifflin Co, p 336, after M R Trabue, *Completion Test Language Scales,* Columbia Contrib to Educ, 1916, no 77 By courtesy of the publishers

from all intelligence levels, but we know that our sampling errors become more and more serious year by year as more children with poorer endowment drop out. There has therefore been some uncertainty as to the average rate of intellectual growth beyond the fourteenth year and as to the relative importance of individual differences in the rate of growth during the period from fourteen to twenty. On the whole, it seems likely that the slowing down of intellectual growth during the teens is rather rapid, and that intellectual maturity, in the sense of all-round capacity to learn to solve problems and to handle new situations generally, reaches its high point in the late teens Some functions involving speed seem to begin to fall off almost immediately thereafter Others

seem to show no loss until about twenty-five years of age; others are probably but little affected till later. Most observers agree that the vocabulary and information tests are least influenced by the passing of years and that scores for tests involving learning ability show the greatest decline. But a good deal depends upon the technique used Scores on army *Alpha* tests certainly decline rapidly in the period between twenty and forty-five, whereas ability to learn through reading seems to decline only slightly. As far as actual ability to deal with complicated tasks is concerned, none of the studies made thus far gives sufficient weight to the factor of increasing experience and seasoned judgment In most occupations, experience adds to, and age subtracts from, ability; the relative importance of the two varies from one occupation to another Gradually declining scores on intelligence tests probably do mean true loss of fundamental learning ability, but how significant this is in terms of the person's total effectiveness is another question.

All this refers simply to *all-round* mental growth. There seems to be a definite optimum time for the development of each perceptual and motor skill. Composite growth curves or curves for the growth of general intelligence are of value, but they always leave important questions unanswered. It seems likely that such figures for specific functions would be of more value than a mere consideration of mental age at each chronological age. The scores for certain specific capacities have recently been published for the *whole life span.*

The difficulty of measuring change during the years of maturity has been noted, moreover, it cannot be too often repeated that intelligence tests, as ordinarily used, were intended for the measurement of mental development in children and they have only slowly and uncertainly accommodated themselves to the situation which the psychologist encounters in testing adults. One may say, after individual or group testing, that a person is certainly up to the average adult or he may say that he is a "superior adult," but he cannot say anything exact In view of the fact that the growth curves seem to slow down in the late teens, our whole

comparison of the levels of intelligence among adults has to depart from the ordinary method of reckoning in terms of mental age One adult who is brilliant and another who is merely bright may differ as much relatively as a ten-year-old and an eight-year-old child, yet this might be impossible to express quantitatively in terms of mental age. Almost always, therefore, comparisons of adults are made not in terms of mental age, but in terms of their *rank* or of some other device showing relative positions of one another in test performance.

How early in the child's growth can we predict his adult capacities? Prediction of a five-year-old child's probable mental age at eight, or even at twelve, is usually rather accurate, for the *rate* of intellectual growth under ordinary conditions is relatively constant When can we begin to make predictions? There has been much interest in the formulation of growth curves which will make it possible to tell at *any* given stage, no matter how early, what the individual's intelligence will be at maturity. A number of infant tests have been devised by means of which the child's response to cups, cubes, rings, and other everyday objects may be compared with that of other children of the same and different ages Norms have been published suggesting what the average child of six months, nine months, twelve months, etc., can do. For some time it was hoped that these baby tests could serve as true intelligence tests and that the child's later I Q could be predicted from his accomplishments in the first year Hope of such an achievement seems now to be disappearing because children who have taken such tests in the first year of life have been retested with standard intelligence tests four or more years later, and no relation between the two kinds of tests has been found. This does not belittle the importance of the baby tests for research purposes, for we need to gather and study a large amount of information regarding the early development of mental and physical functions. It does mean, however, that the kind of ability which our standard verbal tests measure cannot at present be estimated from the baby tests. Accurate testing by standard tests can be made when a child is four or five, provided

he has no gross handicap; tests made earlier than this are likely to be inaccurate.

No important sex differences in intelligence have been found.—The kinds of tests used in psychology do not, in general, show important differences between the sexes, even where such differences are to be expected. Not only general ability, as shown on intelligence tests, but most of the more specialized tests in the field of perception, memory, etc., give nothing clear or consistent regarding sex differences In those few fields where differences are large, they are probably due chiefly to differences in training. Tests in which strength is important do, of course, give differences, but even these are not as large as is ordinarily assumed.

Moreover, most differences of an intellectual sort which have been found bear an obvious relation to known educational factors. Boys surpass girls on most information tests and on most tests of ingenuity and reasoning; but closer analysis of the materials used in such tests shows that they are drawn mostly from masculine pursuits toward which boys are headed. Girls, on the average, surpass boys, particularly in the early years, in vocabulary and in grammar, and in the school period they are usually well ahead in spelling, in history, and in most subjects in which the use of words is important (comprehension, recitation, composition, etc.). Boys still have greater freedom for activity, are allowed to run wild to a greater extent and to cultivate a wider range of interests, whereas girls receive somewhat more intensive training in domestic and scholarly pursuits where they are closely in touch with the mother and the teacher. At least, it is worth noting that most of these differences which are rather clear in childhood and early adolescence begin to disappear when the two sexes work under conditions of approximately equal intellectual stimuli, as in senior high school and college. It may be, of course, that there are intellectual sex differences even at this level, but they have not been discovered by any reliable technique.

When we turn to emotional differences, differences in interest and enthusiasm, the evidence is harder to evaluate, for we have

less exact methods of measuring these characteristics. However, great differences in interest are evident, being found just as much in leisure-time activities, such as reading, as in preparation for life work. To what extent differences in education and in life plan are responsible for these differences in interest is a matter of opinion. Such biological differences as would be involved in a strong constitutional maternal drive would, if established, be of great importance. Such differences might, for example, be responsible for the relatively greater interest of women in children and in everything that concerns children. But most civilizations with which we are familiar train little girls in motherly attitudes from such an early age that any true separation of biological from social is out of the question.

The real differences in interest probably do influence, year by year, the mental habits, the ways of thought, of men and women; they probably do not alter total intelligence, but they help to cast it in different molds. The same is true of *every* interest in relation to *every* growing mind.

For many practical purposes intelligence may be measured and the results may be used without asking about the exact nature of the functions which are being measured These tests were originally found useful in connection with school systems, and have now been found to have many uses also in vocational guidance, personnel work, and other "life" situations Yet this leaves us in the dark as to what intelligence really is. Practically all definitions in the early days of mental testing were broad and general: "the ability to adapt oneself to new situations"; "the ability to think conceptually," etc.

One of the most widely accepted definitions of intelligence is in terms of the *ability to learn*, and experimental evidence directly supports such a definition. A group of normal average eight-year-old children were compared with a group of subnormal children ten to sixteen years old whose *mental age* was also eight. The two groups learned a skilled task at *exactly* the same rate.

Cf. Fig. 92, showing learning curves when the mental age of the two groups was equal.

A year later they were studied again, and now the normal children were ahead because they were *mentally nine years old*, the subnormal group, being older and nearer its upper limit, had

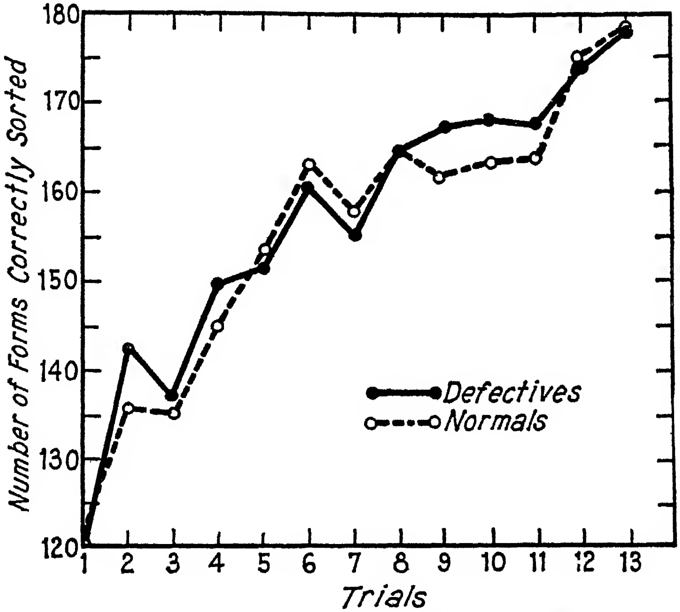


FIG 92 —Learning in normal and mentally defective children Practice curves, in a simple test in which geometrical forms were to be sorted. The two groups were so selected that at the beginning their average *mental age* was the same, the *older* group having very much *lower* I Q 's The two groups learned at the same rate, suggesting that ability to learn depends on mental age, rather than on brightness alone or chronological age alone From H Woodrow, *J Educ. Psychol*, 1917, vol 8, p. 92. By courtesy of the editor, the author, and Warwick and York, publishers

gained less in the year. From evidence such as this we conclude that *ability to learn a complex task* is closely related to total intelligence as shown in *mental age*.

How is ability in one function related to ability in other functions? The task just referred to was a complicated one, requiring the sorting of geometrical forms. It thus involved perception of

the shapes and the piles, rapid discrimination and appropriate co-ordination of hand and eye. The question now arises whether all these functions are present in exactly the same *degree* in any given child. Could not one child make good discriminations but be less skillful in his motor coordination? The very fact that the task involved *different kinds of functions* means that it must be considered only as a preliminary study in relation to our problem The tests themselves were complicated mixtures of materials making all sorts of demands on the child The correlation of one complicated thing with another, even when practically perfect, cannot tell us accurately what the elements of intelligence are, how they are put together, or what their relative importance may be.

In comparing large numbers of people, all mental abilities are found to be interrelated to some degree.—Is there such a thing as "all-round ability"? Is there one thing which is *common to all tests*, a general factor which will appear whenever intelligence is involved? This leads to *correlations*; a correlation is a mathematical statement of relation between different scores. Spearman suggested as early as 1904 that we should study the interrelation between scores on different tests and thus find what common factor runs through a test series If, for example, a person competes with ninety-nine others in various tests of association, memory, and reasoning, and if he stands near the top in all, we conclude that some factor of general ability runs through all of his separate test scores. This, says Spearman, is "general" ability

Spearman's view of intelligence can be expressed graphically by the symbols $G + S = A$, where $G =$ general ability, $S =$ special ability, and $A =$ an aptitude which can be measured. Suppose an individual's aptitude in a given task, such as immediate memory for difficult prose reading, is determined about 50 per cent by his *general* all-round ability, and about 50 per cent by his *special* knack or capacity for that particular thing. One would expect to find a certain positive correlation between his ability in this function and his ability in some other function—for example, playing checkers—*if* the latter function also depended to an equal degree upon the general ability. To be sure, playing checkers is very differ-

ent from recalling difficult prose, and Spearman takes this into account by saying that the S which appears in the first case is absolutely different from the S in the second case. But comprehensive general ability will enter into both functions, so that if one knows that certain persons are above average in ability to master difficult prose, one would be, in the long run, more often right than wrong in predicting that they will do well in their efforts to learn to play a good game of checkers.

Some functions are, to a high degree, dependent upon general ability; others to only a slight degree. If we consider, for example, the rather astonishing fact that a person's vocabulary score correlates highly with his score on intelligence tests, this will mean that the formula for the description of the ability to give definitions of words would be $\mathbf{G} + S = A$. On the other hand, certain special abilities, such as artistic aptitudes, appear to be controlled primarily by *special* gifts rather than general ability, so that a person's actual success in artistic effort ought to be described by $G + \mathbf{S} = A$. The relative sizes of the G and S in any case show to what extent general and special ability enter into the task. Most abilities which have been measured are to some extent correlated with one another because there is some G along with each S.

Intermediate between general ability and certain very narrow specific abilities, there are some very important abilities which are less broad than the former but not so narrow as the latter. Many different kinds of *verbal ability*, as shown in tests of vocabulary, word-opposites, ability to fill in missing words in sentences, etc., are correlated to a high degree even when the formal *processes* are entirely different; for example, finding the opposite of given words is highly correlated with success in giving the gist of what one has read. Many different kinds of verbal ability are grouped together by high correlations, a fact which has led to the designation of verbal ability as a "group factor." In the same way there are rather high intercorrelations between different *number abilities*, and so on for several other kinds of ability relating to certain specific subject matters. Ability to deal with spatial relations, with

musical tone, with color, etc., may constitute group factors Group factors appear to be partly hereditary, partly the result of the individual's interest. An intense interest in a thing may give one the ability to attend to it closely and learn all about it, and to practice it with enthusiasm Special incentives and special opportunities may increase certain abilities a great deal, but definite limits are set by the person's heredity. The expert musician knows that constant practice is the price of success; but great individual differences in musical aptitude, i e, in *ability to profit by such practice*, will nevertheless appear.

The extraordinary degree to which the ability to *understand words* is correlated with the ability which our tests measure is shown by a psychiatrist's report of the correlation between Stanford-Binet mental age and ability to follow directions in the routine physical examination. Examining normal and feebleminded boys between five and eleven years of age, he asked them to bring the forefingers of the two hands together, to point to the nose, to stand on one foot, to stand on tiptoe, to sit down, to stand up straight, etc. We seem to have here simply routine compliance with a routine order. Actually, however, it proved possible to separate degrees of comprehension. "Point to your nose" means an entirely different thing to a bright boy of eleven and to a dull boy of five. The whole hand, for example, may be brought up against the nose, palm inwards, in such a way as to flatten the nose. Here the boy grasps "more or less" what is wanted. The degree of comprehension of each command is gauged on a five-point scale. With almost 400 cases, the scores on the responses to these simple commands agreed extraordinarily well with the Stanford-Binet scores obtained by the same boys

From such studies it is reasonable to conclude that intelligence is made up of (a) general ability, (b) group factors, (c) very specific factors. There is general ability, recognizable and measurable in most intellectual functions, but supplemented by group factors and specific factors which vary in importance in different tasks. The ability to write a sonnet is partly due to general ability,

partly due to a group factor for skill in handling words, and partly due to the specific knack for writing that particular kind of poem

The discussion has a further practical value in increasing our emphasis upon "special abilities." The fact that a certain child will never be brilliant in school is important, but oftentimes less important than the detection of some particular aptitude which may serve as the basis of his life work, or some hobby which may become the chief joy of his life. In the same way, the discovery of special disabilities may be made quite early, and corrective work undertaken; this is important because clumsiness and apparent stupidity may lead to feelings of inferiority or to social maladjustments.

SUMMARY

Individual differences between children in degree of brightness are studied by individual verbal tests, such as the Stanford-Binet, which give an intelligence quotient found by dividing mental age by chronological age Performance tests measure somewhat different ability from that measured by verbal tests; group tests are applied when the number to be examined is large. All forms of intelligence as measured by tests increase rapidly in childhood. Scores on standard verbal tests, such as the Stanford-Binet, taper off in the late teens Sex differences in intelligence test scores are explainable in terms of differences in training Many of the differences in intelligence between people of different ages from twenty years onwards are explainable in terms of their different mental habits There is such a thing as general intelligence, in the sense that all tests of intelligence agree to some extent with other tests. This is the basis for Spearman's "G." The explanation of this finding is obscure. However, it is of practical value to emphasize that there is such a thing as general ability, and also that special abilities must be recognized and encouraged early in life.

REFERENCES

Elliott, R. M (Ed), and others, *The Minnesota Mechanical Ability Tests*, 1930

Freeman, F. N , *Mental Tests*, 1929

Gesell, A., *Infancy and Human Growth*, 1928.

Pintner, R , *Intelligence Tests* (rev. ed), 1931.

Terman, L. M , *The Measurement of Intelligence*, 1916.

PROBLEMS

1. Attempts have been made to devise tests in which results will not be affected *at all* by schooling What do you think such tests would be like? What will they measure?
2. From a sociological point of view, Mr X is a normal person, he earns a living running a steam sterilizer and he does it well. His I Q is 65 and the examiner says he is feeble-minded. How do you reconcile these facts?
3. Most of the items included in intelligence tests are obviously "trivial" Can you think of any reason why such items are better for test purposes than serious life problems?

CHAPTER XIX

HEREDITARY FACTORS IN MENTAL GROWTH

Mental traits depend both upon heredity and upon environment.—The sciences which tell about man do not describe him as he is found in one fixed and unvarying environment. Even if there were no individual differences in hereditary characteristics, we should like to be able to say exactly what the human body would be and how it would work in a specified climate with a specified diet and regimen; actually we cannot do this, even in respect to the simplest anatomical characteristics. A few years ago we spoke of "characteristic" racial differences in stature. Everyone knows that Scandinavians are tall and Japanese are short The Japanese government, however, has recently published statistics on Japanese children who have been reared on the west coast of North America in and near Seattle and Vancouver. At the six-year level these children average an inch taller than children of corresponding age in Japan, and the difference between those born in North America and those born in Japan increases consistently year by year until in middle adolescence the North American group is three inches taller. Such facts may be worth keeping in mind when trying to define the "biological" or hereditary characteristics of man, especially when we are dealing with those delicate problems which we call psychological. It is not only difficult to tell what a man's personality or temperament will become in a changed environmental setting; it is also difficult to formulate exact laws in psychology because we have not, as one writer has well put it, "measurements of the environment."

We can of course say with reasonable confidence that color blindness is hereditary in most cases because we know that differ-

ences in environment make but little difference, whereas differences in heredity make huge differences; but relatively few psy-

FIG. 93.—Identical twins. Individuals whose heredity is identical. When aged as well as when young, identical twins bear striking resemblance to each other in their physical characteristics. Upper picture from D. Fairchild, *J. Hered.*, 1919, vol. 10, p. 388. Lower picture from A. E. Wiggam, *J. Hered.*, 1923, vol. 12, p. 311. By courtesy of the editor.

chological characteristics are as simple as color blindness. Most personal characteristics of adults are profoundly influenced by the

social environment in which they have grown up. It is immensely important to find a valid way of getting at what is truly hereditary.

Identical twins, who have exactly the same heredity, are very similar in intelligence.—Psychologists have come to the conclusion that in the study of many basic traits they cannot get really accurate results unless they can hold either environment or heredity *constant*. Since it is manifestly impossible to hold environment "constant" in any real sense of the term, they have been forced to give attention to those special cases in which heredity is constant. This means the study of "identical twins," for it is only in these individuals that nature gives us material for the study of persons whose heredity is absolutely the same.

In about three out of every four pairs of twins the individuals are no more alike in the long run than are ordinary brothers and sisters. But the fourth pair results from a peculiar and special sort of embryonic development. After several steps in development from a *single* fertilized ovum, two points of growth are set up and two separate embryos develop These two embryos really have identically the same heredity, being derived from the union of the same two cells The nervous systems, the glands and vital organs, are as nearly identical in the two as we could ask. Even the rate of growth in such twins—not merely general gain in length and weight, but gain in specific aptitudes of eye, ear, hand, etc.—shows marked parallelism between the two. Compare Fig. 94. When the two members of a pair of identical twins are given different training, we have an extraordinary opportunity to compare the relative importance of hereditary factors and environmental factors In experiments by the method of "co-twin control," one twin is given intensive training in a particular function, such as the ability to climb stairs, and the other is given no opportunity for such practice until later. This experiment, tried with two baby girls, gave remarkably clear-cut results. One of the twins was given practice in stair climbing beginning at forty-six weeks, and by fifty-three weeks was proficient At fifty-three weeks, the other twin, who had never been on the stairs, was given a chance to climb. Her performance at the start was im-

mensely better than the other's at forty-six weeks, and she caught up to her in one week's practice. A similar experiment in the handling of wooden cubes was carried out, and a third involving the intensive training of one twin in language. In all cases, the non-trained twin made a much better beginning when her oppor-

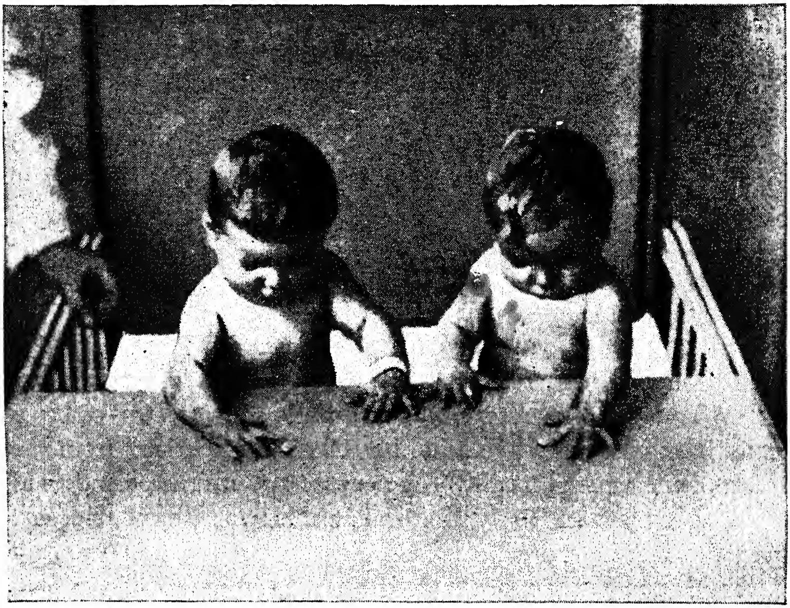


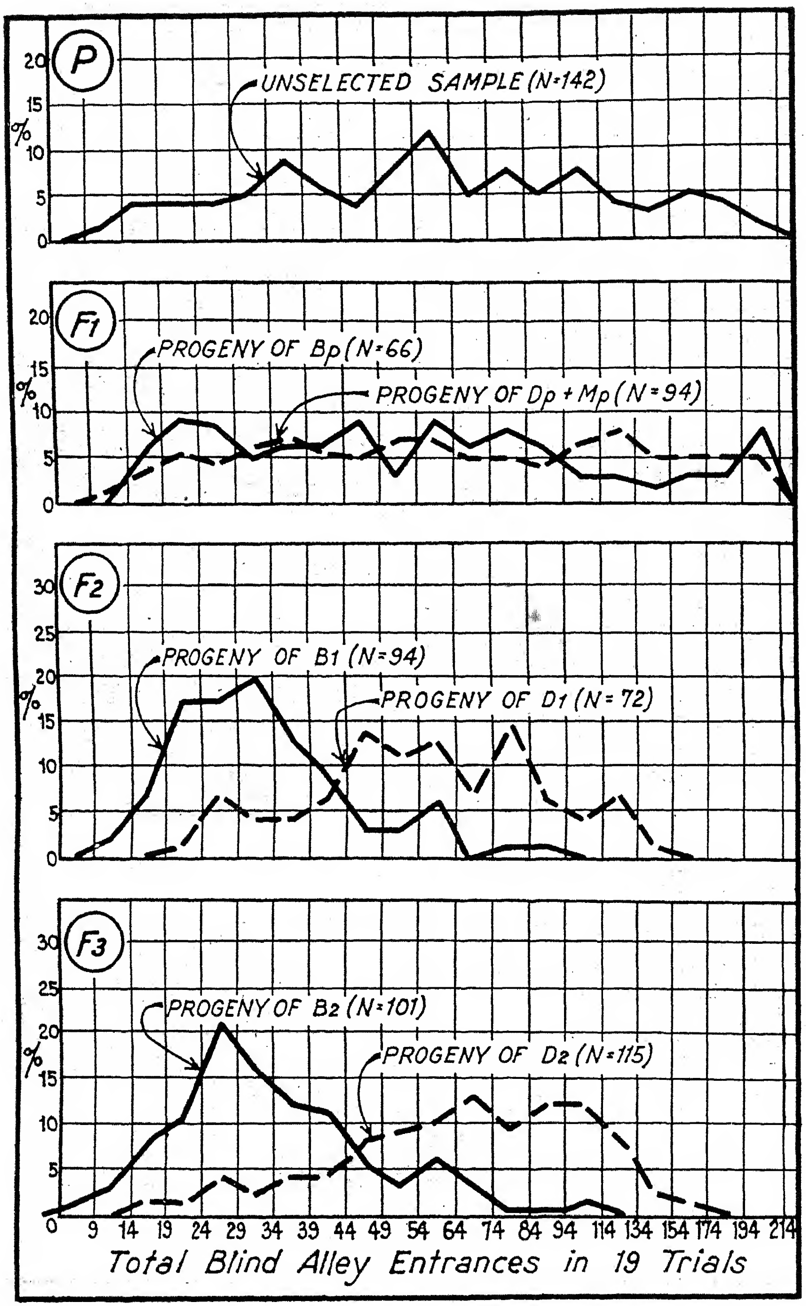
FIG. 94.—Identical twins, age 38 weeks, approaching pellets. Note the identity of their approach to the pellets. The correspondence in their use of their hands, even to the angles of their fingers, is remarkable. It is especially to be noted that it is with the *opposite* side that there is such correspondence, the right side of one and the left of the other. From A. Gesell and H. Thompson, *Genet. Psychol. Monog.*, 1929, vol. 5, p. 11. By courtesy of the editor and the authors.

tunity finally came. In other words, her achievement depended largely upon superior capacity in terms of *growth*, and the speed with which she overtook the other showed that a good deal of what *seemed* to be due to training was really the result of growth going on in the trained individual. The twins were growing in the same way and the training was less important than it might appear.

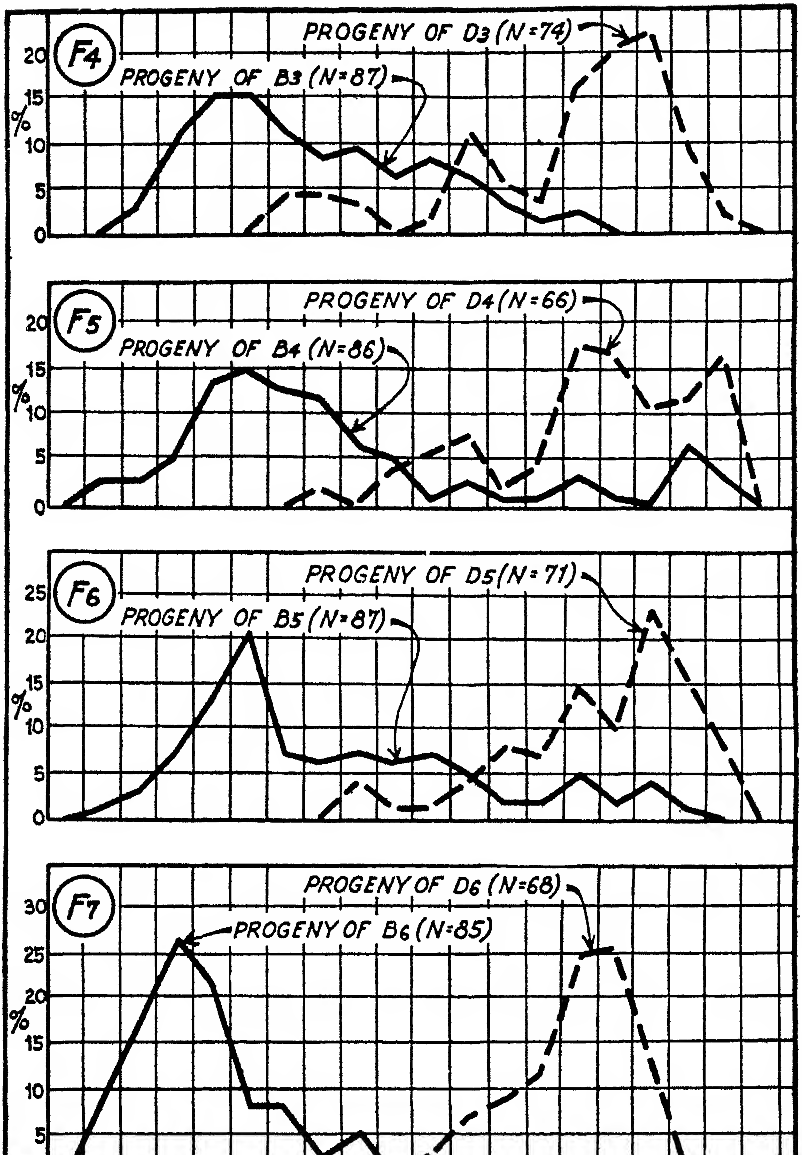
Unfortunately for science, identical twins not only grow up

together, are treated much alike, dressed the same way, sent to the same school, and so on, but they are so handled that they are usually dependent upon each other and influence each other profoundly. The mere fact that identical twins closely resemble each other in intelligence, usually differing in I Q by only a few points, is therefore not conclusive. Heredity and environment should work hand in hand in such cases, and it is hard to tell exactly how much is due to environment. For this reason special attention is given to *studies of identical twins reared apart since infancy.* A good way to approach the heredity-environment problem is to find out how much difference there is between identical twins who have been separated early in life and who for many years have lived in different kinds of environments. Recent efforts toward discovery and measurement of such cases have yielded a considerable amount of interesting information. In physical traits, despite long years of entirely different kinds of life, the resemblance in these cases is remarkable. Among eleven pairs of identical twins reared apart who have recently been studied psychologically, the twin resemblance in intelligence has been proved to be quite close in most cases, despite the different environments. Yet, since the intellectual resemblance is not quite as striking as the *physical*

FIG 95—Inheritance of intelligence; the effect of selective breeding on maze learning in white rats By mating "bright" with "bright" and "dull" with "dull," rats were produced after seven generations that were very bright (designated *B*), and others that were very dull (designated *D*), with little overlapping of the bright and dull groups. Note the gradual separation of the two curves. The base line is the same for all the graphs and is a scale of brightness-dullness; it shows the *total number of entrances into blind alleys in 19 trials* in a maze, the fewer the number of errors made by an animal, the "brighter" he is The vertical scale represents the per cent of the group making the errors at each point on the base line *N* is the total number of animals in each group *P, F1, F2,* etc, represent the successive generations The *two* distributions in *each* generation after the *P* group represent the offspring of very bright and of very dull animals of the preceding generation. Thus in the *F7* generation, "Progeny of *B6* (*N*=85)" means the 85 offspring of the very brightest of the bright *F6* (preceding) group, and "Progeny of *D6* (*N*=68)" means the 68 offspring of the very dullest of the dull *F6* group. The parents selected to produce the next generation were always the "brightest of the bright group" and the "dullest of the dull group," except that in the *F1* generation a large number of dull parents (*Dp*) were combined with a few average or mediocre parents (*Mp*). By courtesy of R. C. Tryon.


P
UNSELECTED SAMPLE (N=142)
F1
PROGENY OF Bp (N=66)
PROGENY OF Dp + Mp (N=94)
F2
PROGENY OF B1 (N=94)
PROGENY OF D1 (N=72)
F3
PROGENY OF B2 (N=101)
PROGENY OF D2 (N=115)
%
0 9 14 19 24 29 34 39 44 49 54 64 74 84 94 114 134 154 174 194 214
Total Blind Alley Entrances in 19 Trials

a


F4
PROGENY OF D3 (N=74)
PROGENY OF B3 (N=87)
F5
PROGENY OF D4 (N=66)
PROGENY OF B4 (N=86)
F6
PROGENY OF D5 (N=71)
PROGENY OF B5 (N=87)
F7
PROGENY OF D6 (N=68)
PROGENY OF B6 (N=85)
%
9 14 19 24 29 34 39 44 49 54 64 74 84 94 114 134 154 174 194 214
Total Blind Alley Entrances in 19 Trials

b

resemblance, the different environments must be credited with some influence upon the I.Q.

In Chapter II we considered briefly the nature of heredity The reader will recall that the *germ cells* contain the tiny rod-like particles upon which hereditary traits depend. These tiny particles, the *chromosomes*, are capable, when in the right environment, of directing the growth of an embryo. The two parents contribute equally to the pattern from which the new individual is derived.

Animal experimentation suggests that an animal's intelligence depends on many hereditary factors.—To get a clear view of heredity in relation to a psychological problem, we shall refer to a prolonged study of the hereditary aptitudes of rats in maze-learning; the figures on pages 394-395 show graphically the results of selective breeding of "bright" and "dull" rats for eight generations The experimenter found some animals which learned the maze with a small number of errors, and others which learned it only after making a great many errors. By continued inbreeding of the bright ones he produced a rather consistently bright "race" of rats, while by the inbreeding of the dull ones a stupid "race" (with respect to this problem) was produced. Brightness and stupidity in this case are hereditary

Human intelligence also depends on a large number of hereditary factors.—The theory of heredity shows why there is a resemblance between children and parents, but this resemblance will necessarily vary greatly from case to case. In the case of any individual, the 48 chromosomes which went into his make-up came half from the father and half from the mother Since the mechanism of heredity provides that 24 of the chromosomes that went into the father's make-up, and 24 of the mother's, will be lost (for the number does not go on doubling with each generation), the degree of resemblance between father and son will be limited both because the child must resemble the mother as well as the father, and because some of the factors involved in the father's make-up are actually now lacking. The resemblance of brothers and sisters is usually higher than the resemblance of a child to one parent. Moreover, children of the same parents have

not by any means the same actual hereditary traits, because each child receives 48 chromosomes, some, but not all of which are the same as those received by another child The degree of resemblance between children must vary between two extremes, the first being that of complete identity in every trait, the second that of the widest deviation which can exist within stock to which both parents belong (the more different the stock, the wider the range of possible difference).

Paradoxical as it may seem, heredity may sometimes make a child unlike his parents. The difference between parents and children is often cited as evidence against the significance of heredity. Yet a child with light skin, born of two rather dark mulattoes, would not be cited as proof of the importance of "environment" We know that *variation around the average skin color of the two parents is to be expected* in accordance with the laws of heredity; any given child may be either darker or lighter than its parents, simply because the child's *heredity* is derived not *from its parents alone,* but *from the entire stock* to which it and its parents belong Study of heredity leads one to expect rather large and important differences between parents and children In fact, if differences between parents and children were *consistently* slight, we should have a right to explain almost everything in environmental terms since parents undoubtedly influence children more than anyone else. It is the case of marked superiority of the child over its parents, or of marked inferiority to its parents, that reminds us, as does the dark-skinned child of mulatto parents, that heredity is an impersonal sort of thing, necessitating the study of the whole family, stock and race. In the same way, a child's brightness is not just an average of the brightness of the two parents; it is a composite in which all the traits of the stock may be shuffled and recombined, the results following the "laws of chance" as in dice or cards, yet having a definite trend which is consistent despite individual fluctuations.

Human intelligence depends partly on the social environment.—We have described psychology as a biological science, but it is also a *social science*, since it deals with interaction of

persons. Many of the biological laws which one would like to lay down seem to be upset by the presence of a social environment in which these laws are expressed We respond to one another as well as to impersonal objects Errors have at times been made through failure to remember how powerfully the social environment works upon us. From the point of view of the biological sciences, the central problem is the structure and function of individual organisms. But the relations between persons are as important as the persons themselves. This requires that we consider two viewpoints, first a *biological* and second a *social science* viewpoint.

The contrast between a purely biological approach and an approach which considers the individual make-up largely as a result of a social environment may be illustrated by the problem of racial differences. From the former point of view, stated in its most extreme form, an individual's inherited dispositions, such as the endocrine make-up, play a predominant part in his emotional characteristics. The Nordic race is thus temperamentally distinct from the Mediterranean race because, in the long evolutionary process, adaptation to different environments has been carried through Different glands, different chemical balances, even different structural characteristics of muscle, nerve, and brain have evolved Puberty begins earlier in the Mediterranean races than in the Nordic, with important consequences in the whole emotional life of the adolescent and the young adult, and with consequent important effects upon the organization of the family. Society is a product of the characteristics of persons, which in turn are a reflection of their physical dispositions. From this biological point of view, the Negro not only has his own fundamental emotional trends, but his intellect is basically different from that of whites, both quantitatively and qualitatively. His inferior scores on intelligence seem an inevitable consequence of his different kind of brain. Even if his brain were able to master Nordic civilization, there would be many points at which a difference in attitude, and consequently a failure of understanding, would be bound to ap-

pear Carried one step further, the argument may run: "East is East and West is West, and never the twain shall meet."

It will be noted that one has to assume much about hereditary trends in order to make the above argument hold. Even if he is not making a study of social influences, the psychologist inquires first as to the established facts regarding hereditary differences between two races, say Nordic and Mediterranean. Differences in emotional trend do, indeed, appear, as is evident in differences in onset of puberty. He must, however, inquire as to the diet and regimen of the racial groups being studied, and as to the possible effects of climate and of geographical factors. For example, the psychologist may want details regarding Norwegians or Icelanders living in Sicily or northern Africa, or regarding Sicilians or Spaniards living in Iceland or Norway He would even be satisfied if he could get accurate data on these groups as immigrants in the United States He finds, however, that no such data are in existence; and he is troubled to discover that many of the elementary differences mentioned in the above discussion disappear under conditions where diet or climate is constant for the two racial groups (An obvious case appears in physiological studies of Negroes in the northern part of the United States.) The psychologist finds himself, at the end of the inquiry, uncertain as to the facts about heredity presupposed in the foregoing discussion.

Race differences in sensory and motor capacities are certainly slight, and even if well established could scarcely be shown to be truly innate Much attention has been given to the supposed superiority of primitive peoples in smell and touch; yet such superiority as they have seems to result mainly from their intensive training to meet particular needs in their own environment and way of life Tests of smell and touch show no definite superiority of one race over another. Many suggestions have been made as to race differences arising from the fact that rhythm, tone, color, and design are used in such different ways among different races. Certainly primitive peoples differ in their art forms and are responsive to different kinds of sensory stimulation. When studies

of relatively simple material are made under experimental conditions, some differences seem clear, but they show in many ways the influence of training and other social factors A recent attempt has been made to compare the color preference of little children of the Negro and white races, with the result that the only clear differences appeared in the *interest* in the colors The Negro children seemed relatively interested and enthusiastic, and showed more decided preferences than did the white. Yet this may reflect the relatively poor and starved environment from which they came, rather than anything inborn.

Lacking evidence, then, for the biological argument, the psychologist turns to a concept used by historians, ethnologists and other social scientists. The concept of "culture" defines the modes of interrelation between members of a community The "culture pattern" is the way in which society is organized; it includes the organization of family, clan, and state, as well as that of each group in relation to material property and the physical facts with which man deals in adjusting himself to his environment. Every child born into a group is shaped into characteristic modes of response The kind of obedience, or conformity, demanded by the family and the group is, itself, a part of the culture; Eskimos and Japanese mountaineers, for example, would be in agreement that to discipline a child is cruel or in bad taste, and that those who love children let them have what they like, whereas Spartans and Romans believed that discipline is the first principle in sound education. These ways of bringing up children were themselves learned from those who came before The child's language, its ethical standards and conceptions of truth, the specific things it loves and hates, and even the qualities of its love and hate, are determined for it in large part by the group in which it grows up. Personality, then, is literally shaped and cultivated by modes of interaction which are already part of the civilization into which a person is born. Almost nothing about a Norwegian or a Sicilian is explained by reference to the biological make-up of his race.

We deliberately chose Norwegians and Sicilians as an illustration, for historians tell us that there are groups in modern Sicily

who are descendants of roving Vikings who made their home there in the Middle Ages. Indeed, one can find in the Italian culture of Sicily individuals distinctly more Nordic than some who live in Norway. Little is known regarding the individuals who took part in the great movement which swept the Vikings into Sicily, but a good deal is known about Viking culture, about Sicilian culture, and about the interaction of the two. Following the principle of making the simplest formulation which is clear and which does no violence to the facts, we should regard a considerable part of human nature as *culturally determined.*

This will mean going counter to many of our ingrained habits. It will mean, for example, that we shall have to think of the Vikings themselves not as persons *constitutionally* predisposed to roving and ravaging, but as persons whose geographic and climatic setting, whose contacts with other tribes in the course of their long migrations, were aspects of one vast sequence of events, this background, in relation to the tempting spoils easily to be won on the north coast of Europe, was sufficient reason for their naval and military expansion Even national temperament may change as social conditions change The poetic, unpractical people of the Rhineland, at whom harsh men of affairs laughed in 1800, were an important element in the business-like and aggressive Germany of 1900, which British commerce was beginning to fear.

The argument may well be regarded as only preliminary, and direct experimental evidence in its favor may reasonably be asked. One instance of such experimental evidence will, therefore, be offered. There is no case of national or racial retardation as conspicuous as that of the American Negro on the basis of standard intelligence tests About two hundred experimental studies have compared Negroes with whites All age levels, both sexes, and nearly all occupational and social economic levels have been compared. There are scarcely any exceptions to the generalization that the Negro makes lower intelligence test scores than the white We shall now try to find out why this is so

For experimental purposes we really need a group of Negroes who have shared since birth the fullest cultural opportunities, and

have participated in all the typical social contacts of white persons, political, economic, and educational In so far as our experiment is to be sound, it must have groups which are socially comparable. But this first requirement of fair comparison is denied us, since no large group of Negroes can be found of whom the

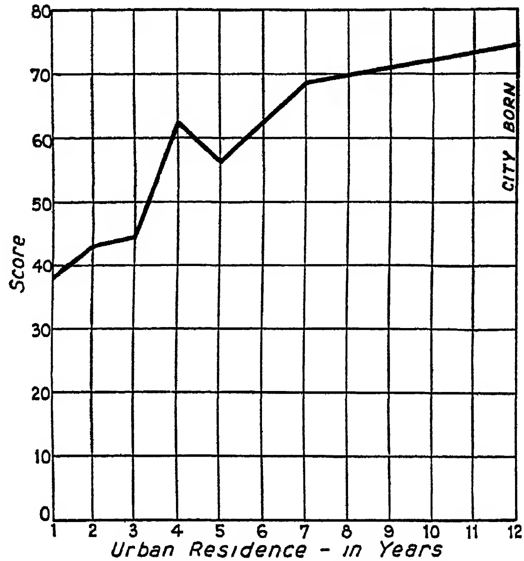


FIG 96—Effect of city environment on intelligence test scores The National Intelligence Test was administered to 776 twelve-year-old Negro boys in three southern cities, New Orleans, Atlanta, and Nashville Of these boys, only 359 had been born in the city; the rest had come from rural environments at different times Dividing the boys into groups on the basis of the length of time they had resided in the city (city-born having an urban residence of 12 years) and computing the mean intelligence test scores for these groups, we see a direct increase of intelligence with longer residence in the city Courtesy of O Klineberg.

above is true. Lacking this, we must resort to the second best method We compare groups of Negroes with one another, subdividing a group of several hundred into small groups which have had *various amounts* of education or social opportunity comparable to that which white persons receive. We can, for example, take twelve-year-old boys, some of whom have had only rural schooling, some of whom have had one year of urban schooling,

some of whom have had two years of urban schooling, and so on. In this way, the degree of success on the intelligence tests may be compared with the amount and type of schooling received. The chart above shows the progression from the level achieved by rural school boys to that achieved by boys whose schooling was all received in a large city. The longer the period of good schooling, the higher the score.

The next step in the reasoning is to ask whether the schools of these cities were equivalent to white schools The answer is that the school year is the same, but that the schooling which the teachers themselves had received averaged several years less in the colored schools than in the white; that the school equipment cost less than half as much; and that, summarizing it all in a single figure, the amount appropriated for an individual Negro child in a Negro school was about a third as much as it was for an individual white child in a white school

Therefore, we need a further check on our original assumption This will consist in comparing Negro boys in the southern cities with Negro boys in a northern city in which Negroes and whites go to the *same* schools, for example, New York, and we find that the intelligence test scores of white and Negro twelve-year-olds are very similar. This does not close the argument, but it leaves the "burden of proof" on those who are sure of *innate* racial differences in intelligence

In another comparison of racial types, seven samples of groups from the rural population in central and western Europe were compared—some in France, some in Germany, and some in Italy. Physical measurements were made to determine the racial type of the individuals and their families, and a group of performance tests was administered The result showed that all seven of the rural groups differed substantially from the urban groups; but when they were compared with one another, consistent racial differences failed to appear. For example, some samples of the Nordic race were inferior, and others were average. Similarly, the different samples from the Alpine and Mediterranean races gave widely varying results. It would seem that any true general differ-

ence between these three subdivisions of the white race was slight or completely absent. Similarly, the cases were classified according to nationality—French, German, or Italian—and again good samples and bad samples were found in each. It would seem, then, that neither racial nor national differences could be regarded as clear-cut. There remains the possibility that the averages of the *entire* Nordic, Alpine, and Mediterranean races differ significantly It is quite possible, for example, that, if the Alpine stock could be studied as a *whole*, it would prove to be on the average superior or inferior to the Nordic. Students of immigration are concerned with this problem of the relative frequency of the different grades of intelligence in different subdivisions of the white race, and these differences are in many ways important sociologically; yet obviously we need an immigration policy in which the capacities of *individuals* are carefully weighed, not just racial averages.

The present approach is much less final, less simple, less quantitative than a biological approach; and, if taken seriously as a scientific approach, it results in much less willingness to make dogmatic assertions. It might almost be called a critical approach, because it is not offered in quite the same confident spirit in which physical explanations are offered. To give a thing a "cultural" explanation results in less definiteness than giving it a physical explanation, simply because the laws of cultural transmission are much less clearly established. The results of a cultural approach are largely in the form of cautions. Our discussion, then, could easily be stated negatively by saying that intelligence is *not* simply a hereditary quality of persons or races It is partly a result of the degree of educational opportunity received by an individual; this, in turn, is a product of the cultural relations (social and economic competition between races, etc.) prevailing at a given time and place. The student will see that our cultural interpretation is not really a *complete interpretation* at all, but an attitude of doubt, a questioning habit of mind, which claims little now but looks forward to the discovery of social laws which describe influences at work upon individuals in the family, in school, in economic and political competition.

The upshot of this is to make us doubt whether "human nature" as we see it day by day is determined in any clear way by heredity This means that if, by some device, one could bring up a Cro-Magnon baby, the child of an ancient caveman, in New York, it would be indistinguishable from New Yorkers of the twentieth-century type (cf. page 22), and that if babies born today could be brought up thirty thousand years ago they would make good hunters and artists of the Cro-Magnon type So important are social factors in human life that thirty thousand years of accumulated civilization can be telescoped into a few years in the education of a child. The inventions, discoveries, and insights which have come to people over this period of a thousand generations, in the form of language, literature, art, science, government, and so on, are capable of assimilation, one might almost say, in "capsule form," by the child as it grows up. Both *quantity* and *quality* of intellect as well as personality and temperament may in fact be largely shaped by social forces Probably quantity of intellect is less affected than quality or the direction to which intellect is turned, the "habit of mind," the special activities for which the mind becomes trained in a particular environment.

In the U. S. individual differences in I.Q. seem to depend more on differences in heredity than on differences in environment.—We have attempted a sketch of two viewpoints regarding the interpretation of intelligence test results; they may seem to be opposed, but it is more likely that they are necessary supplements of each other. Every reader is entitled to his own emphasis. However, an author has an obligation to give an evaluation of the evidence as he sees it, and a personal view regarding heredity in relation to intelligence will therefore be given, starting from the beginning and summarizing the whole story.

The elements on which heredity depends interact in an intricate way in shaping characteristics of the growing individual. Few, if any, characteristics like strength, speed, or skill are derived from a single chromosome; and few chromosomes, if any, fail to influence thousands of physiological and psychological traits. More-

over, as the child grows, the environment interacts with him in a complicated way. For most purposes, we may regard the environment of the embryo as "constant" when considering such characteristics as general intelligence, because the variations in temperature, nutrition, etc , are usually rather small relative to the variations in the quality of the heredity No trait is determined by heredity alone and none by environment alone, but in the case of the newborn child we shall say that the prenatal environment has varied within such small limits as to be relatively unimportant as compared with heredity. But after birth, variations in environment are large; and when, a year or two later, variations in the complexity and in the quality of the social environment become great, it is reasonable to regard variations in the rate of intellectual growth as dependent in some measure upon these environmental factors. To determine accurately the relative importance of heredity and environment in causing individual differences in intelligence would require, first, the determination of the range of intellectual variation shown by a given human group all living under approximately the same environmental conditions; second, measurement of the variations which a group with the same constitutional make-up might show when subjected to a wide range of social environments; third, considering the two sets of facts together and appraising the relative importance of variations in the biological as compared with the social influences.

The study of foster children has gone a good way toward giving us this sort of data. With reference to the population of the United States and the social conditions now prevalent, we may say, on the basis of the study of many hundreds of foster children whose intelligence has been carefully measured after living in a *favored home*, that variation in stock is somewhat more important than is variation in environment. There are various ways in which the facts may be stated. One convenient way is to say that the I Q may be raised on the average only about 5 to 10 points by transplanting the child from an average environment to a distinctly good environment. Moreover, heredity and environment tend to vary in the same direction; a positive correlation between good

stock and good environment appears in such studies because the more intelligent parents are able, in the long run, to provide better homes. Environment is important, but probably not as important as heredity. These statements are not applicable in the case of grossly under-privileged groups

There are some cases where environment makes but little difference. There are, for example, many feeble-minded children for whom little can be done. On the other hand, many average or bright children seem to be able to make about as much out of an average environment as they could from a superior one There seem even to be some cases of the "compensation" type, where an inferior environment actually spurs an individual on to special effort. Finally, it is important to emphasize that not merely the general qualities of the social environment, but the specific factors which have facilitated growth of the kind of ability tested by intelligence tests, need to be considered. Changes of as much as 30 points in I Q occasionally come about as a result of a marked change of incentive or the sudden introduction of new opportunities with the kind of verbal material which intelligence tests so greatly emphasize

Occupational differences in intelligence are partly hereditary, partly environmental.—Just as the markedly inferior individuals arise for the most part from definitely inferior stock, so the definitely superior seem to come mostly from stock that is well endowed The extent to which such superiority may be due to superior home surroundings is not known absolutely, but the general trend of the evidence may be noted as follows: A recent study in California of a thousand gifted children has ascertained the professional, economic, and social status of the parents, and has shown that intelligence is more or less correlated with the parents' success in the competitive economic order The professional homes contributed many times their share of gifted children. Such generalizations as these relate, of course, to large groups of children A better way to study the facts is to present overlapping graphs showing the distribution of intelligence at each of four or five economic levels, so that individual differences within each

class receive due attention. The graph shown below seems to be typical.

It is very difficult to evaluate heredity properly in interpreting data such as these. The I Q. is reasonably constant in most children from year to year; but since the environment is fairly constant for

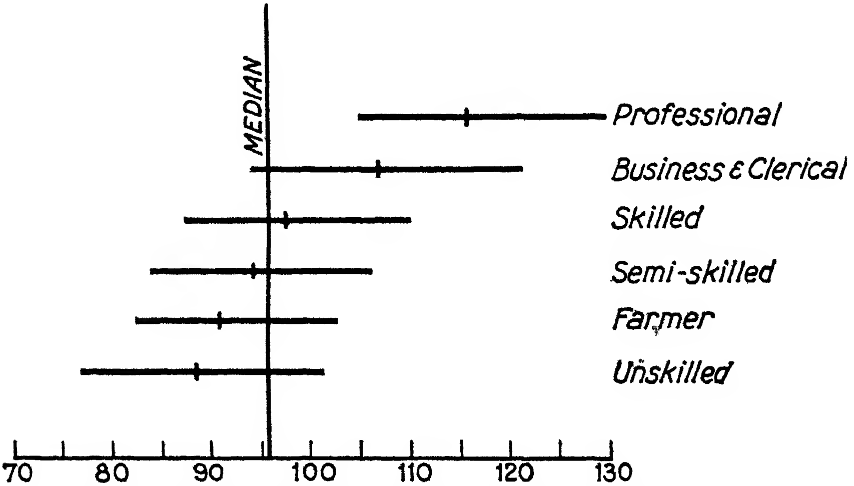


FIG. 97.—Relation between the intelligence of children and their fathers' occupations Men in the "higher" occupations have children of higher intelligence levels. The numbers on the base line of the chart stand for intelligence quotients The horizontal lines show the *range* of the middle 50 per cent of the children of that classification (i e, excluding the top 25 per cent and the bottom 25 per cent), the short vertical lines represent the *median* (middle case) of each group The long vertical line labeled "median" shows the midpoint for the whole group of over 6600 rural New York grade school children Note that the ranges of the different groups overlap considerably, showing that a child on one level may do better than many on the "higher" levels From M E Haggerty and H B Nash, *J Educ Psychol*, 1924, vol 15, p. 568 By courtesy of the editor, the author, and Warwick and York, publishers

a given child, it is impossible to tell from this whether high I Q 's are due chiefly to hereditary or to environmental factors, or to both in about equal degree.

Sometimes we can get fairly direct evidence as to the importance of social factors, in particular, the influence of schooling. The canal boat children of England get almost no schooling at all Although these children are nearly up to normal intelligence

when they are little, the I Q falls rapidly from year to year, and at early adolescence the children are mostly in the "borderline" and feeble-minded groups The tests do not show *merely* the results of schooling; yet in such a case not only must we admit the lack of constancy of the I.Q , but we must admit that the decline of the I Q. (due to the slow progress in mental age as chronological age increases) depends in large part upon the failure to get the usual school training.

Similar results are shown in the case of an American rural group which is isolated to an extraordinary degree from the outside world, a group in the Virginia hollows There is no community life, even of the most primitive sort. Though testing as normal or dull-normal in their early years, the children test mostly as borderline or as morons at age ten. When asked who the next neighbor was, a gesture pointing across a range of hills might serve as an adequate reply. Some things the children described as near, other things as far; no exact terms to express distance—such as foot, yard, mile—were known to them. The words used in the test at the twelve-year level were completely over the heads of these children It may be granted that the stock is of below-average endowment, as is the case in many isolated communities, but the degree of retardation should be evident by four or five years of age If the I.Q. sinks more and more as the child grows older, this must be attributed to the difference between the surroundings and those surroundings with which we are ordinarily dealing.

It may be of interest in this connection to compare the results obtained in testing Negro recruits during the War; they made as a rule the scores characteristic of dull-normal individuals or morons. The non-language tests which were used included two, to test whether the recruit recognized that a picture of an electric light bulb lacked a filament, and that a tennis court lacked a net This was a good deal to expect of a plantation hand living in a one-room shanty, with a tallow dip for a light and with only homemade recreations of the kind which would please a little child.

In order to get a direct measure of environmental forces of

this sort, scales to measure *socio-economic status* of families have been devised. These assign a certain amount of "credit" for ownership of one's own home; possession of automobile, phonograph, radio; subscription to magazines; and varying credit for windows, bathrooms, central heating, etc Emphasis necessarily has to be on the material possessions rather than on the less tangible ones One elaborate attempt has recently been made to survey a wide range of elements contributing to the social environment; it contains in all nearly a hundred items. "Telephone," "artistic prints," "summer vacation," and "ownership of home" are characteristic of the favored homes. College graduates with incomes of over $5000 receive average ratings of 83; successful business men, 73. Families known to child guidance clinics score only 47, and dispensary cases score 34 The I Q.'s of the children are correlated with these scores. The positive relation between socio-economic status and intelligence of the child is clear This throws only a little light upon the problem of the influence of environment upon intelligence test performance, because, as we noted, the intelligence of parents is itself an important factor in determining the social status of the home; but with gradually improving quantitative methods of this sort, mathematical methods for evaluating the data will appear.

What do these differences in intelligence in occupational groups actually mean in practice? Sixty per cent of the population falls between I Q. 90 and 110. Most persons in this group can benefit from intensive training and become highly skilled workers, the degree of their success depending not merely on their intellectual level, but on incentives and many personality traits Probably 110 is about the lowest score which justifies an adviser in urging a boy or girl to go to college; 120 is a fair figure for the professional or business man of average attainment. Here again, though. special interests and personality traits are of outstanding importance In many situations earnings may even be negatively correlated with intelligence beyond a certain point The sheer fact that one is more alert to the interesting qualities of his profession may make him less intensively oriented toward the highest possible earnings.

appears. A large number of persons are evidently working below the highest economic level at which they might be successful. Thorndike noted that the most striking fact appearing in such comparisons is the waste involved in the wide scattering of *levels of work* at each *intellectual level.* A great many are trying to do work which they are not equipped to do; others are frittering away their energies on tasks much beneath their capacity.

From the evidence sketched above it might appear that in some problems a cultural or social science approach is required, and in others a biological approach. In talking of identical twin resemblance it might seem that we could dispense with the cultural approach, and in describing the test scores of socially handicapped groups it might appear possible to dispense with biological concepts altogether. Yet it would be dangerous ever to rely on one group of concepts to the neglect of the other. In the study of the Negro boys mentioned on page 402 there were huge differences between groups in relation to educational opportunity, but even here there remained within each group large *individual differences.*

We may summarize the facts in this way. Among children of rather similar heredity most of the variations in intelligence will be due to variations in environment, while among children from rather similar environments most of the differences will be due to variations in heredity. At any given time and place the relative importance of the two will vary. In the United States at the present time the study of children transferred at an early age to foster homes suggests that more of the existing variability in intelligence in our population is due to variability in heredity than to variability in opportunity. This general statement, however, relates to the United States as a whole. In some small cities social and economic conditions may be so uniform as to make hereditary variability as much as ten times as important as the variability of environment, while in some rural districts as much as one-half to two-thirds of all the variability in intelligence may be due to schooling.

The dependence of intelligence upon heredity is illustrated in the case of mental defectives.—Gradations in I.Q. show that people can be divided into bright, average, and dull only in the

same sense in which they can be divided into tall, medium, and short. The mental defective is, from a psychological point of view, simply an individual falling below a certain arbitrary point on the distribution curve for the whole population.

For convenience, those with an I.Q. below 70 are classed as feeble-minded. They may be grouped as morons, I.Q. 45 to 70; imbeciles, I.Q. 20 to 45; and idiots, I.Q. 0 to 20. Special social importance attaches to the morons and to the borderline groups whose I.Q. falls between 70 and 80. Since the borderline cases are numerous and their mental difficulty is less easily noticed by

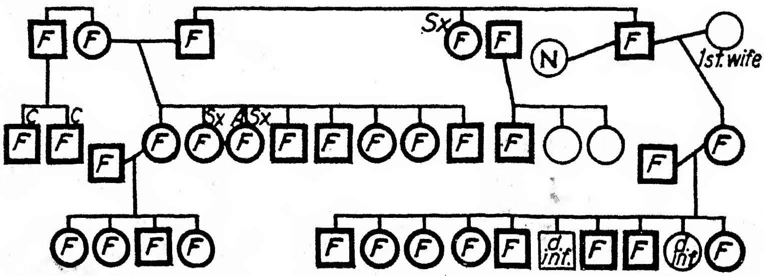


FIG. 98.—Pedigree of a defective family. Squares, male; circles, female; *F*, feeble-minded; *N*, normal; *Sx*, sex offense; *C*, criminalistic; *A*, alcoholic; *d. inf.*, died in infancy. Chart reads down; within a family order of birth is shown by reading from left to right. The only persons in the bottom line who were not clearly defective were those who died in infancy. From H. H. Goddard, *Feeble-mindedness: Its Causes and Consequences*, The Macmillan Company, p. 171. By courtesy of the publishers and the author.

average people, they may easily get into trouble (delinquency, etc.) or be victimized by the unscrupulous. Remembering that in the Stanford-Binet tests sixteen years is considered the level of intellectual maturity, we see that an I.Q. of 75 means, in an adult, the mental age of a twelve-year-old. For the most part, the I.Q.'s of defectives are as constant as those of normal children, or even more so; so that from a careful test of a defective child it is possible to predict approximately the mental level which will be reached upon the attainment of any given chronological age, and to set a probable upper limit of development.

Feeble-mindedness usually makes its appearance early in life.

The belief that the great majority of cases are hereditary is confirmed by the studies of family trees of mental defectives. When several feeble-minded children appear in one family we may ordinarily assume that there is something inherent in the germ plasm which will continue to produce low-grade intellects generation after generation. The typical chart on page 412 shows the carry-over of such defect for several generations.

Pedigrees such as these are plentiful in the work of investigators who have dealt chiefly with obvious low-grade defectives whose differentiation from the normal is clear-cut When, however, dull or borderline individuals are studied, the use of the terms "normal" and "feeble-minded" becomes, as we have seen, unsatisfactory; in fact, the great majority of the parents of the children in one large hospital for mentally defective children turned out to be a few points above 70 I Q., the technical point of differentiation between feeble-minded and normal. All that we have said regarding the multiplicity of factors responsible for general intellectual level applies also to lower levels. Brains vary all the way from very good to very poor Many cases of mental defect show obvious evidences of brain defect, but it is only in the more pronounced cases that gross abnormality is evident at a glance.

In some cases there is an unevenness in the rate of growth; some functions grow at relatively normal speed, others are retarded. The epileptic feeble-minded child is likely to show wide scattering on test scores—some functions have been greatly retarded, others hardly impaired at all This stands in contrast to the all-round or general retardation of the ordinary mental defective whose test scores do not scatter much Epilepsy sometimes causes this kind of *failure of development* and in other cases causes the actual *deterioration* of minds which have made a reasonably good start until the onset of the epileptic seizure; and in some cases epilepsy and mental defect are inherited together

Though heredity is the chief cause, other factors appear in the causation of mental defect.—Disease affecting the brain may sometimes cause arrest of development (compare Fig 99). Injuries to the head occasionally limit the brain's capacity to grow

normally. The fluid normally contained in the ventricles (hollow spaces) of the brain may increase so as to cause excessive pressure on the brain tissue and prevent it from developing normally; those suffering from this condition are called hydrocephalics.

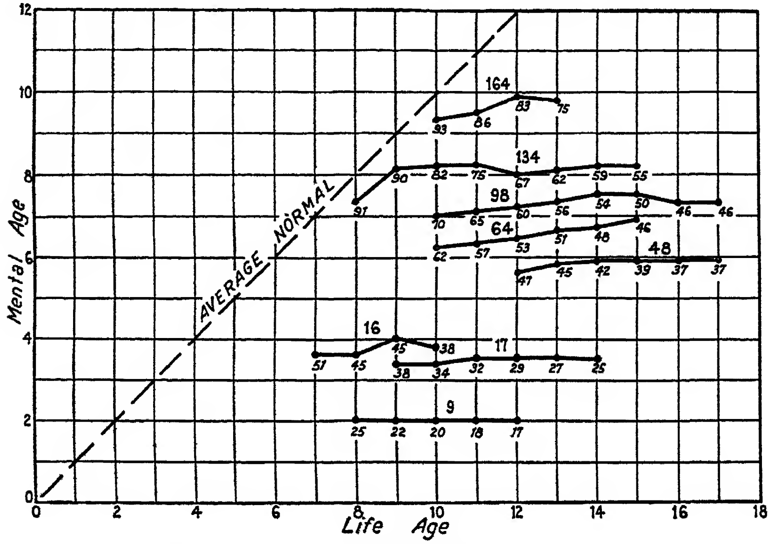


FIG 99—Arrested development of feeble-minded children The intelligence of normal children would be expected to develop as indicated by the diagonal broken line. The short black lines are the individual curves for each of several feeble-minded children whose mental age was determined annually over a long period of time Note that these curves are all flat, they do not rise to indicate a higher mental age as the child grows older, which would be the case if the children were developing as normals do The large number over each of the curves is the case number in the investigator's file The small numbers under the curve, at each year of life age during which the testing was conducted, show the I Q. at that time. Since mental age is constant while chronological age increases, the I Q has to fall From E A. Doll, *The Growth of Intelligence,* Princeton University Press, p 107, also *Psychological Monographs,* 1920, vol. 29, No 131 By courtesy of the editor and the author

In a general way, the differences in *size* of brain have been found to be related to differences in intellect in the evolutionary sequence, and the same general comment applies to some comparisons between human beings in respect to intellect. Comparisons in size of brain among normal persons do not seem to have much bearing on intelligence level, but a brain *substantially* less than

normal size indicates an intellect that is below par. The failure of the brain to develop beyond a pound or so in weight (as against the average weight of three pounds) results in a low-grade mental defective of a type shown in Fig. 100. These *microcephalics* usually attain at most a mental level comparable to that of a

FIG. 100.—Two microcephalic girls. Microcephaly occurs about twice as often in men as in women. There is generally more than one case in a family, although all the children are not necessarily microcephalic. The girls in this figure are not related to each other. Note the characteristic shape and diminutive size of the head. On the theory that the condition is caused by too early closure of the various parts of the skull, operations have been attempted to enlarge the cranial cavity, but they have not resulted in any increased development of the brain. From C. Bernstein, *J. Hered.*, 1922, vol. 13, p. 38. By courtesy of the editor and the author.

child of one, two, or three years. They usually learn but little. This condition, though not classifiable with the ordinary hereditary kind of feeble-mindedness, seems also to be hereditary, since the aunts and uncles of such persons often show the defect even if the parents do not. Sometimes the children of white parents fail to develop the physical characteristics of members of the white race, and show a deviation in the direction of Mongoloid appearance

which causes them to be called *Mongolians.* It is commonly remarked in the clinic that "they all look alike." The characteristic slant of eye and relative position of nose and cheek give an appearance like that of a child of Chinese parents, except for skin color. The origin of this condition is unknown. Chinese intelligence, as shown by tests, is as good as ours, but the tendency of a white child to develop Mongolian features usually accompanies not more than an imbecile level of intelligence. Most interesting of all are the *cretins*, in whom complete or partial failure of the

A B

FIG. 101.—A. 8-year-old cretin, completely helpless. B. Cretin 11 years old. This individual died at the age of 38 but her appearance was practically unchanged throughout her life. Cretinism is that type of feeble-mindedness which comes of failure of the thyroid gland to function properly. From M. W. Barr and E. F. Maloney, *Types of Mental Defectives*, P. Blakiston's Son and Co., p. 165. By courtesy of the publishers.

thyroid gland (cf. page 60) causes an all-round defect which is suggested in Fig. 101. Cretins are greatly retarded intellectually. True cases of cretinism are rare today, owing to the alertness of the medical profession to indications of this defect and the administration of thyroid-gland feeding from an early age. The best method is direct hypodermic injections of *thyroxin*, a substance prepared from the thyroid gland. The degree of success of such

feeding in relation to mental condition varies greatly from case to case. Some children benefit greatly in mental as well as in physical condition; others, though helped physically, seem mentally unaffected.

The great *majority* of mental defectives are physically undistinguishable from normal persons.—Though the height, weight, and general health of the feeble-minded do not average quite up to par, most of them are in no sense "freaks." If the student should gather that a *large proportion* of defectives have peculiar bodies, such as we have just described, this account would do more harm than good. Mental tests were devised in the first place because it was found that even the best of judges could not estimate intelligence merely by looking at a person. The student is urged to try his own luck in guessing the I.Q.'s of the group of boys shown in Fig. 102. Some of them are dull, others average, others bright. The actual I.Q.'s appear in a footnote on page 428. Psychologists, teachers, and physicians can guess I.Q.'s slightly, but only *very* slightly, better than a chance method (e.g., a roulette wheel) could "guess" them. This statement holds for *individual guesses*. Since with large groups of "judges" who work with the same photograph the errors in one direction tend to cancel those in the opposite direction, the *group judgment* (averaging the estimates of different judges) will be much better than those of individual judges, but still far from dependable.

SUMMARY

The importance of heredity in relation to intelligence appears clearly in the case of identical twins. Animal experiment supports the view that the biological capacity for learning sets limits upon what education and environment can do. Intelligence, however, is not based on any single hereditary element but on the interaction of many. The social environment also contributes powerfully to intelligence. The organism cannot unfold and react intelligently in

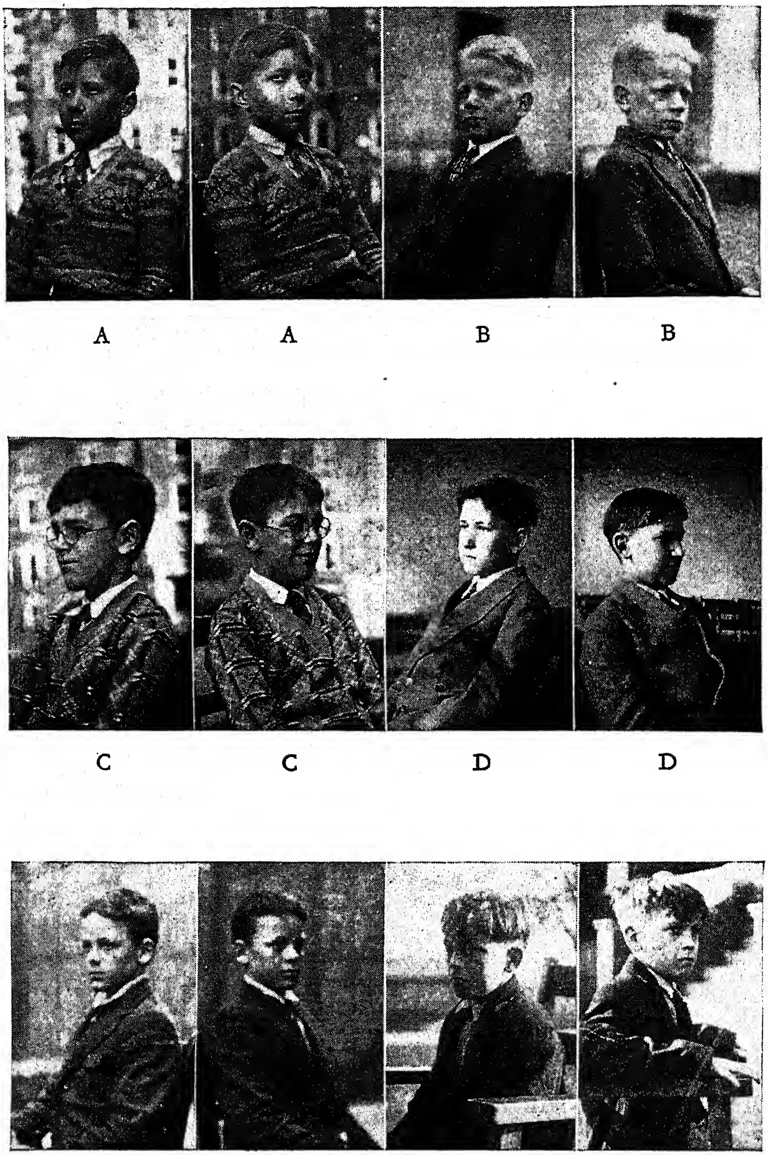
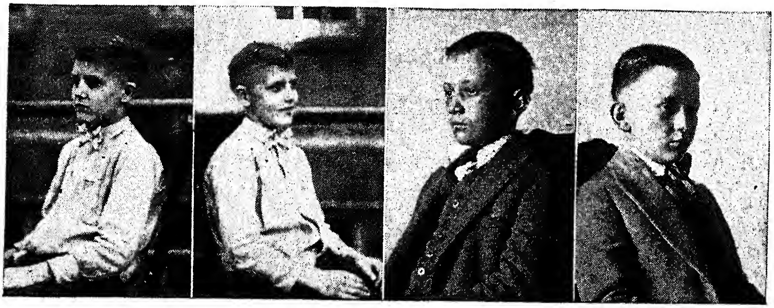
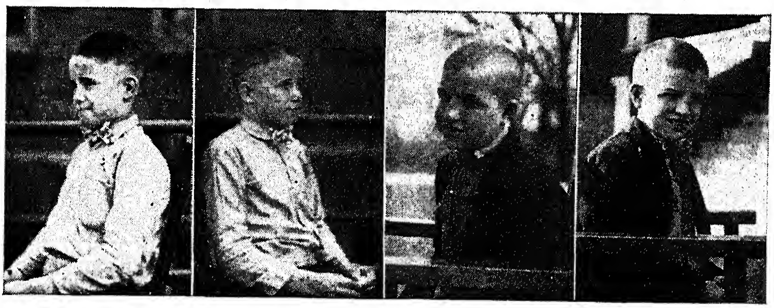


FIG. 102.—From the two photographs of each boy, guess the intelligence quotients. The test scores are given in a footnote on page 428. From P. C. Gaskill, N. Fenton, and J. P. Porter, *J. Appl. Psychol.*, 1927, vol. 11, pages 395, 400 and 402. By courtesy of the editors and the authors.



G G H H

I I J J



K K L L

social situations unless social training is given. In the long run, heredity is probably more important than environment in explaining individual differences, but the relative importance of the two depends on social conditions. Most mental defect is primarily hereditary but environmental factors are important also.

REFERENCES

Ellis, H., *A Study of British Genius,* 1926.

Goddard, H H., *Feeble-Mindedness: Its Causes and Consequences,* 1914

Hollingworth, L S, *The Psychology of Subnormal Children,* 1920.

National Society for the Study of Education, *Twenty-seventh Yearbook,* 1928

Tredgold, A F., *Mental Deficiency* (5th ed.), 1929.

Woodworth, R. S, *Psychology* (3rd ed), 1934.

PROBLEMS

1. Make a brief summary of the evidence with which you are familiar concerning the importance of hereditary factors in the development of intelligence Are you dissatisfied with any portion of this evidence? What additional research would be desirable?
2. In what ways is it legitimate to compare chimpanzees with children? What are the most striking similarities? What are the most important differences? Comment on the following statement· "The average adult chimpanzee has a mental age of about three, while an intelligent dog has a mental age of two and a half."
3. Suppose "philosophers were kings," and each person's education were exactly proportional to his native endowment How would this affect the distribution curve of intelligence in our whole society?

CHAPTER XX

CONDITIONS OF WORK

HERE and there in the preceding chapters attention has been given to conditions helping or hindering the normal flow of activity, for example, muscular tensions were seen to be important for mental work, and sleep was seen to affect the whole course of the curve of forgetting It will be worth while to stop here to consider more closely a few of the factors which affect the efficiency of work. Our concern is with relatively objective factors upon which experimental data have been secured.

FATIGUE

Physical work results in the accumulation of waste products in the muscles and in the blood stream.—In physical work (cf. Figs. 103 and 104), there is not only a special strain on certain muscles, but also the manufacture of waste products through the rapid wearing out of muscular tissue, and the liberation of these poisonous substances into the blood stream faster than they can be eliminated. The result is that most persons doing physical work really suffer mental as well as physical fatigue in the sense that their brains are more or less clogged with waste substances. Part of this can be avoided by properly spaced rest periods; some factories give a five-minute rest period every half hour.

Another method of studying work is through the *metabolism*, or rate at which body energy is used (cf. Fig 104).

In psychology we are not of course concerned only with the effects of the heavier forms of manual labor Our problem is with subtler and more troublesome matters. For one thing, the sus-

tained tension of certain muscles may give a sense of weariness or even depression which may not represent generalized fatigue at

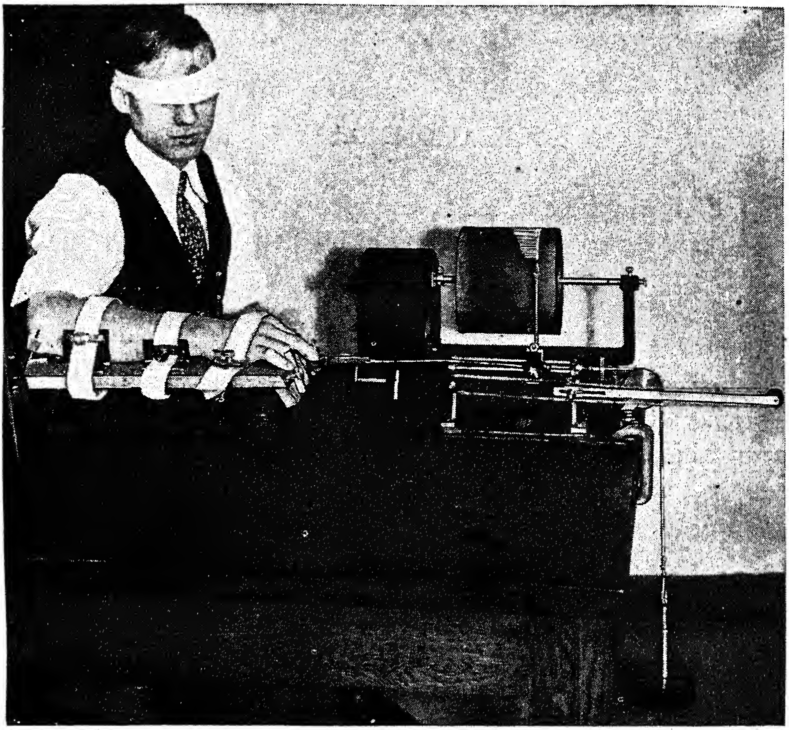


FIG. 103.—Apparatus for studying fatigue, the Mosso ergograph. In some studies of conditions affecting the ability to perform work it is necessary to have work of a very specific nature done, so that minor differences in ability may be more readily seen. This apparatus requires the subject to raise and lower a heavy weight which is attached to a single finger by means of a strap and pulley system, as shown in the figure. The arm, the hand, and the other fingers are strapped down to prevent them from participating in the work being done. The subject may even be blindfolded so that he cannot see how much he has done. The distance the weight is lifted is recorded directly on the smoked drum and as fatigue sets in the strokes can be seen to get somewhat shorter.

all. Finding a more relaxed posture or frequently changing one's posture may make all the difference in the world. What seems to be mental fatigue turns out to be physical fatigue.

Even so, is there not such a thing as actual fatigue of the brain itself as it works? The answer is difficult to find. Delicate measure-

ments of the amounts of energy used up in the brain show that these are slight as compared with the amounts used in physical work. For example, copying this page on the typewriter would use at least ten to twenty times as much energy as the brain would use

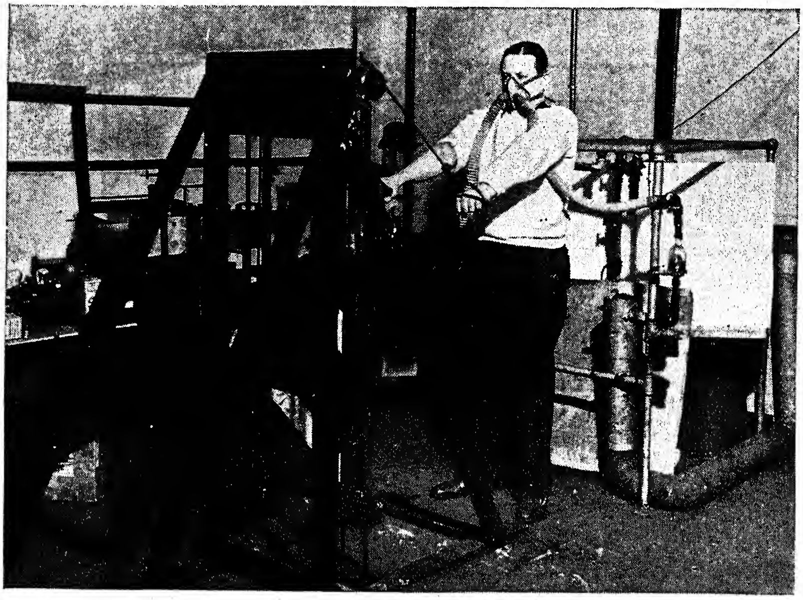


FIG. 104.—Studying the "cost" of work by measuring metabolism. Metabolism, the rate at which the body energy is being used, is a useful clue in the study of work conditions. It may be measured by means of the apparatus shown in the figure. The subject wears a mask while at work. One of the tubes brings air to him; the other carries the exhaled air away through a valve system to large canvas bags (which may be seen behind the subject). Chemical analysis of the air collected in this fashion gives an indication of how much of the oxygen in the air was used up, which in turn sheds light on the *cost of the work to the body of the worker*. This "cost" may vary from minute to minute.

in a concentrated study of it. Of course the brain, being a delicate organ, *may* be fatigued, that is, partially incapacitated, even through such exceedingly slight loss of energy, but the chemistry of the matter is complicated, and "loss of energy" does not describe all the facts.

Much that passes for mental fatigue is really lack of interest.—Under strict experimental conditions, what is the true loss

in efficiency in a mental task over a period of several hours? The answer is that if incentives (desire to excel, etc.) are kept fairly constant, it is at about the rate of one to four per cent per hour, in periods of from one to four hours. This is so slight as to be negligible. It is not at all comparable with the actual losses in

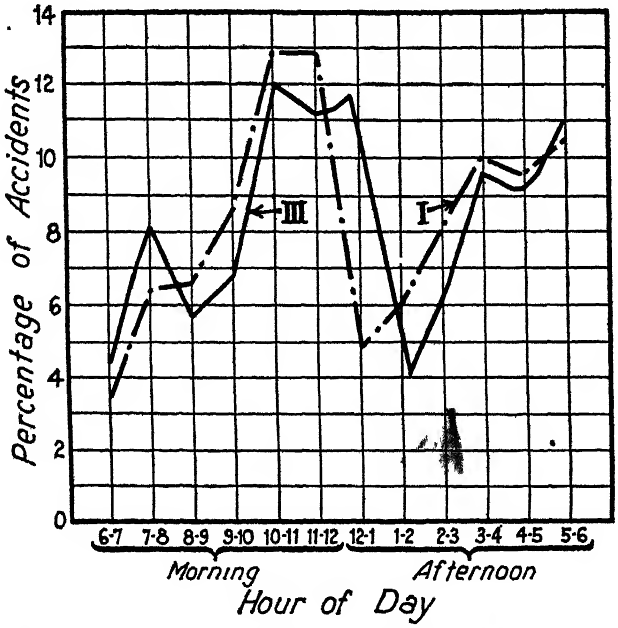


FIG 105a.—Distribution of industrial accidents through the working day Curve I refers to accidents in Germany, all industries, for 1887; curve III is for Lancashire, England, the cotton industry only, for 1908. Compare with Fig. 105b and note how similar all the curves are even though they are taken from such different countries and occupations Notice the general tendency for accidents to increase in succeeding hours both in the morning and in the afternoon From B Muscio, *Lectures on Industrial Psychology*, George Routledge, and E. P. Dutton and Co, p 60. By courtesy of the publishers.

efficiency which occur in the working day. Note the accident rates in Figs. 105a and 105b, which are probably indicators of fatigue. The output of work of both hand and brain workers also shows "steaming up" during the morning, a high point about 11, a depression before lunch, another spurt between 2 and 3 o'clock, and

again a big decline "Fatigue" is thus more marked than the results that we get under *experimental* conditions. In fact, experiment often shows the "steaming up" effect to continue for hours; compare Figs. 106a, 106b, 106c. There is every reason to believe that most of the fluctuations in everyday working capacity are not

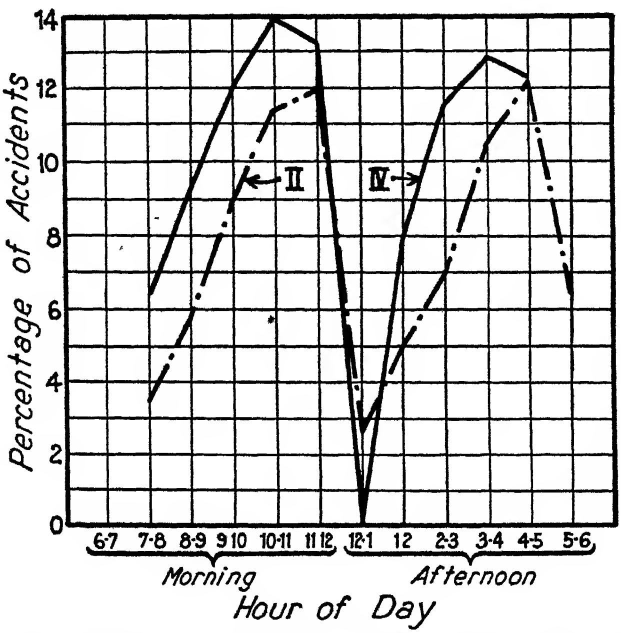


FIG. 105b.—Distribution of industrial accidents through the working day. Curve II refers to accidents in Illinois in 1910, curve IV is for accidents in Illinois in 1911, 1912, and 1913 From B Muscio, *Lectures on Industrial Psychology*, George Routledge, and E P Dutton and Co, p. 60. By courtesy of the publishers.

really due to fatigue, but are a matter of *interest* and of other factors involving incentives In fact, stating this somewhat more broadly, we may say there is evidence that most of what we call fatigue is really inattention or boredom. We say that we simply cannot go on. What we mean is that we do not want to go on In this connection, an experiment was performed in which people were subjected to a temperature of 86° F and a high humidity to see whether it would lessen their efficiency. The result was to

make them uncomfortable, but not to affect their working capacity. However, individual differences must be allowed for; there probably are many people who could not work under these uncomfortable conditions. But for the most part, what passes for mental fatigue is loss of interest, or distaste for the work.

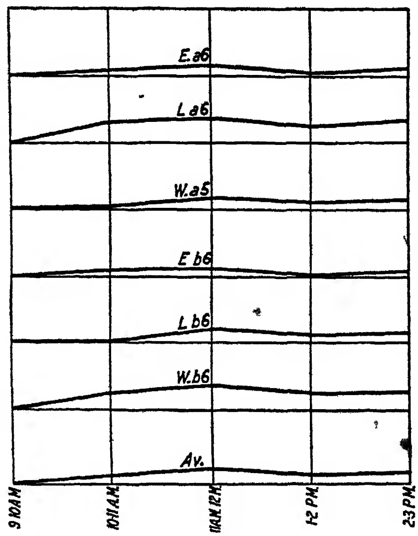


FIG 106a—Efficiency at different hours of the day These curves show the efficiency of school children in addition The first six curves are for different groups of children, the notations on the curves being merely keys to the grade and school The bottom curve is the average for the entire group. These are fairly typical of curves of mental work Note the rise in efficiency through the morning, the noon drop, and the beginning of a slight rise in mid-afternoon. From A I. Gates, *Univ. Calif. Publ in Psychol.*, 1916, vol 2, p. 37. By courtesy of the editor and the author.

For example, a normal "fatigue curve" having been obtained for a group of college freshmen in the classroom, a control group was given an identical task after four days of fraternity rushing, in which they had slept only one or two hours out of twenty-four and had been subjected to a "strenuous régime of humiliation and fatigue duty." The latter curve showed an extraordinary evenness of performance; it showed no resemblance to the "fatigue curve" for the simple reason that the "pledges" believed that failure to

take the task seriously might mean exclusion from the fraternity Similarly, most simple automatic responses seem to fatigue under ordinary conditions. But if precautions are taken to keep *motivation* strong or to supply some other motivation to take the place of the flagging interest as the novelty wears off, the sheer continuation of the work seems to have no effect on efficiency.

Incentives affect the curve of work at every point. The fact that incentives are so important may at times make a purely physio-

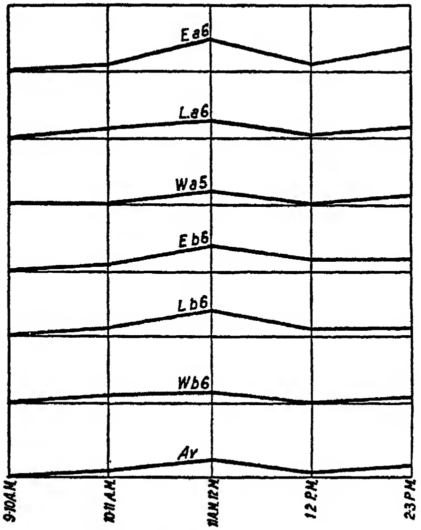


FIG 106b.—See caption for Fig. 106a

logical study impossible Sometimes, in the case of both learning curves and work curves we define a "physiological limit"; but if incentive is increased, the limit is usually pushed up (cf. page 469). Forty type compositors whose average experience was ten years and whose performance had been relatively constant for a long time were offered a bonus if their output increased by a certain percentage; the *average* increase was 78 per cent, and 39 of the 40 men passed the bonus level.

However, it must be remembered that in the face of a difficulty we characteristically throw in additional effort (cf the data on

tensions on page 469). Students of "distraction" have found that a pandemonium of devices for interfering with laboratory work may actually increase the work output. Since the extra effort must use up energy, it is possible that if we had a more delicate measure of the *after-effects* of prolonged work we might find that the

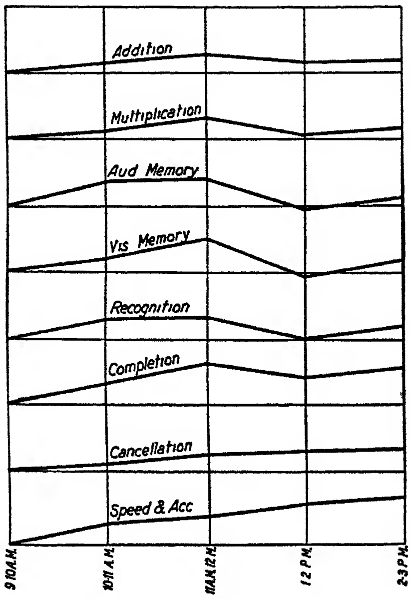


FIG. 106c—See caption for Fig 106a.

organism has been more fatigued than the fatigue curve shows It would be a little rash to advise the student to choose a room next to the brass foundry even if he can read more pages there than in a quiet place

Sometimes the conclusion drawn from such experiments is that if our work is distasteful we should grin and bear it. This, of course, does not follow. In most cases the ultimate results of

The I.Q.'s of the boys whose pictures appear on pages 418-419 are:

A 128	E 119	I 63
B 111	F 36	J 18
C 140	G 99	K 71
D 55	H 171	L 26

making a task more interesting repay tenfold the time and energy involved in making the adjustment. Moreover, the whole habit of "grinning and bearing" is apt to encourage faulty work habits and a "martyr's" attitude toward work; this involves a loss of push and zest which are beyond all price. Boredom is merely one of many kinds of reaction which represents a waste within one's own forces. It may not happen to show in the curve of work at the time, but it is apt to be a cramping factor if it gets to be a permanent aspect of any set of work habits.

"Overwork" is often merely nervous tension or worry.— One hears much about "nerve fatigue." Such conditions represent a great deal of wear and tear, and it is important to see just exactly what has gone wrong In the first place, a *nerve* is hard to fatigue. A nerve can be stimulated many times a second for many hours and still work about as well at the end as at the beginning. It is not the lower part of the nervous system, but the connections in the brain that get fatigued. This fatigue, as we have seen, is slight in the case of intellectual operations. In certain kinds of work carried on over several hours we do begin to get an actual impairment in efficiency, probably something like 50 per cent in the course of a long hard day of uninterrupted mental work. This, however, is unusual. Nearly always such cases are complicated by the tendency to get so wrapped up in the subject that we cannot forget it when night comes We go on wrestling with the topic in the evening and perhaps all through our troubled dreams. The brain gets no real rest; and if this goes on for weeks, it is probably correct to speak of a genuine brain fatigue. Probably some "nervous breakdowns," perhaps 20 to 40 per cent of them all, are due to something like this.

On the other hand, the majority of such cases are not of intellectual origin, but are cases of prolonged internal disturbances, emotional conflicts, worries They involve the endless recurrence of certain ideas and the tension which any prolonged fear involves Weeks of fear will prove fatiguing, no matter what one is thinking about; and the stage is set for a genuine "nervous fatigue" Here the result may look like overwork (in fact, many physicians let

their patients tell them that their trouble is overwork). It is usually overworry. Of course, telling a person not to worry is adding insult to injury; the problem is to find the *cause* of the emotional conflict or the reason why the fear hangs on. Change of scene is good if it relaxes the emotional situation The term "nervous breakdown" is used loosely, and the condition is often due to other things than work or worry. It may be caused by glandular disorder, infected teeth or tonsils, etc. The conditions may produce a state of chronic fatigue in which there is inability to concentrate, apathy about most of the common interests of life, and apprehensiveness about things which to most people seem trivial.

It would seem, then, on the basis of this brief analysis, that the term "fatigue" is being made to do too much work It is a far cry from formation of toxins in the muscles to a prolonged worry.

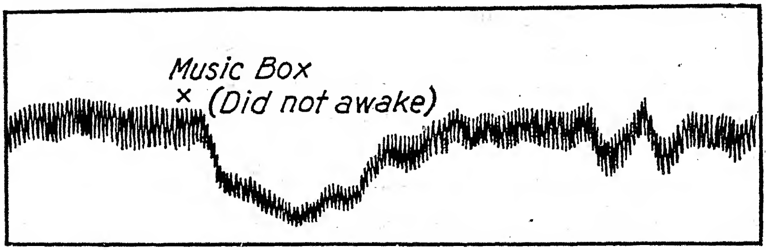
True fatigue leads to sleep, allowing body repair.—To return to the common facts of fatigue. Drowsiness is a normal reaction to any clogging of the brain with waste products There is little doubt that sleep is first of all a physiological brain change

Circulatory changes are probably important among the many which accompany the process of going to sleep, it is a condition of more rather than less blood in the brain This would, in the long run, give a chance for better repair work on the brain during sleep, but it would also mean that the brain could not function in the way we call normal. Changes in circulation during sleep are very evident, by means of the plethysmograph (cf. page 104) such changes may be studied objectively; cf. Fig 107.

In men, however, sleep is greatly affected by habit and circumstances. In fact, experimental studies have been made with persons awake as much as ninety hours at a time Some individuals are capable of varying the daily amount of sleep from as little as six to as much as eleven hours without much apparent change in their physical condition. The factor of habit is conspicuous in relation to our dependence upon quiet, a particular temperature, light, amount of air, and so on. Situations which would be intolerable

when one is in control of his own environment may be accepted in a hospital or camp, and an entirely new set of habits may be rapidly established. In other words, though the waste products in the blood are in a sense a "cause" of sleep, they are a cause only in the sense that they *predispose* toward it; they are helped or hindered by many circumstances. The mere fact of having fallen

A



B

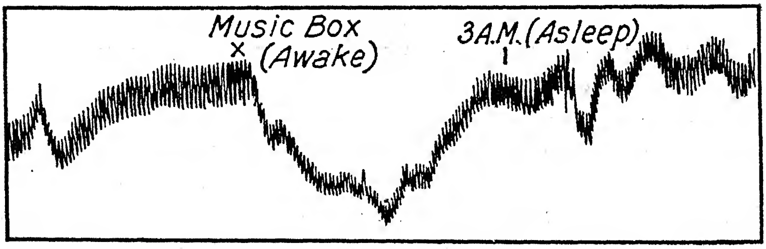


FIG. 107.—Changes in circulation of the blood in response to stimulation during sleep. Though the person tested was asleep, the records show great similarity to the response when awake. These records were made with a plethysmograph, a device for measuring volume of the arm (page 104). The up-and-down strokes indicate pulse; the main outline of the shape of the curve indicates a decrease in the volume of the arm, in response to the music box. From W. B. Howell, *A Textbook of Physiology,* W. B. Saunders Co., 11th ed., p. 266. By courtesy of the publishers.

asleep many times in a particular situation—darkness, warmth, quiet, etc.—may bring on sleep even when one is not fatigued. In fact, the production of only a small part of the total habitual pattern (for example, lying on the floor and shutting the eyes) may produce sleep at any time in persons who have had to train themselves to sleep anywhere at a moment's notice; and this may happen whether or not they are in need of sleep at the time. The

importance of habit is evident in the fact that the sleep of civilized man differs so much from that of primitive man Regularity and rhythm, the assumption that the night is for sleeping and that there should be plenty of sleep—convictions to which civilized man has come—are in contrast with the haphazard and confused sleeping habits of practically all primitives.

Experiments have been performed to test the rate at which we go to sleep and the depth of sleep at various intervals. Some of these measure the intensity of sound required to wake us up. The measurements of depth of sleep obtained by use of varying electrical stimulation for awaking the sleeper give very similar results. They all show that sleep is deepest after an hour or so, and that most people "gradually wake up" during the rest of the night

We do not go to sleep with the whole brain all at once; the brain probably goes to sleep piecemeal. There is some evidence to show that the loss of voluntary movement occurs first while imagination is still quite active. The various functions are lost one by one, the perception of sounds being the last to go. Dreaming, as we noted, is probably related to the partial sluggishness of some brain patterns and the vigorous activity of others. In the meantime, as soon as the body is relaxed it begins to undergo a curious kind of specialized resting, first at one point, then at another. Photographic studies of adults and children, from the time of going to sleep to the time of waking up, have shown that frequent changes of posture during sleep are not the exception but the rule. Each person has a few main postures that he assumes during sleep, and changes from one to another are made at frequent intervals. This is probably not a sign of restlessness; on the contrary, it seems to be a special way of resting. It is impossible to relax all the muscles to an ideal degree at the same time; and the constant shifts in position make possible relatively short, but effective, rest periods for each muscle group in its turn.

As Hollingworth remarks, it is strange that this sleeping state (in which we spend about twenty-three years during a lifetime of three-score years and ten) has never been seriously studied until the last few years. Such studies as the above strongly suggest that

the actual restfulness of sleep and the details regarding the extent to which its recuperative power is used may be of profound importance.

FOOD AND DRUGS

In view of the importance of chemical processes within the body, it is remarkable that so little is known about the psychological effects of diet and of drugs. Ancient manuscripts tell how man may acquire the traits of an animal—courage, for example, from the tiger—by eating the glands of the creature. This is perhaps nothing more than an expression of the general magic-derived belief that by eating an organ which serves a certain function, one can strengthen that function Primitive people in many places eat the hearts of the brave men that they have killed in the hope that courage and strength will come to them; cannibalism often has its explanation in the desire to acquire magically the traits of the dreaded neighboring chieftain Certainly Egyptian and Greek physicians thought that diet bore a definite relation to different kinds of mental functions. Hippocrates, "father of medicine," was explicit about the kinds of diet which should be followed to change the balance of the four elements in the body upon which the patient's mental condition was thought to depend. The doctrine of the four temperaments (in their relation to earth, air, fire and water present in the body) was preserved through twenty-five centuries; and today we find, together with a new scientific foundation, theories of diet based on the assumption that increase in protein, decrease in starches, different balance between various salts, and the like, are important in relation to mental health. With progress in the chemistry of nutrition, some of these earlier ideas have been shown to be strikingly near the truth. Many glandular products of animals are now fed to individuals slightly below par in certain kinds of secretions The torpor of the hypothyroid case, for example, seems to some extent removed by such treatment, even when no problem of intellectual retardation is

involved Research on personality changes associated with changed body chemistry will undoubtedly prove important in the next few decades

Most foods, however, cannot be studied in relation to their *immediate* consequences. The physician must usually wait two or three weeks after a change of diet before noting any clear physical change, and the whole problem is complicated by the fact that so many other aspects of the person's regimen vary.

In contrast to all this, the effects of drugs are usually obvious, and they are frequently measurable. Consider, for example, the effect of eating a meal and the effect of drinking a cup of coffee. The former at once decreases the speed in most simple and perceptual motor tasks from five to fifteen per cent, the latter increases it up to about the same amount. The caffein, however, is eliminated in a short time, whereas the food is burned up as fuel or used to repair waste or build new tissue; its influence may be important long afterwards For reasons such as these, it is possible to write at considerably greater length about the effects of drugs than about the effects of foods, though their psychological importance is probably much less.

The effects of caffein and tobacco appear to be slight on the average, but vary with the type of work and the person involved.—*Caffein* may well be the drug put first on the list. Coffee contains relatively more of this than tea does, but both beverages contain a good deal of it. Strictly speaking, tea contains thein, a very similar alkaloid.

Sixteen subjects, tested over a forty-day period, were required to do a variety of mental and physical tasks, some involving speed and accuracy of perception, as in canceling every "r" on a page, some involving steadiness of hand, some involving speed and accuracy of muscular coordination. Every day each subject took a capsule containing a preparation; half of the days, caffein was present in this preparation; the other half, it was absent There was no clue from taste or odor. Thus the effect of the subjects' expectations could be controlled. Three grains of caffein (the amount contained in the average cup of coffee) slightly accelerated

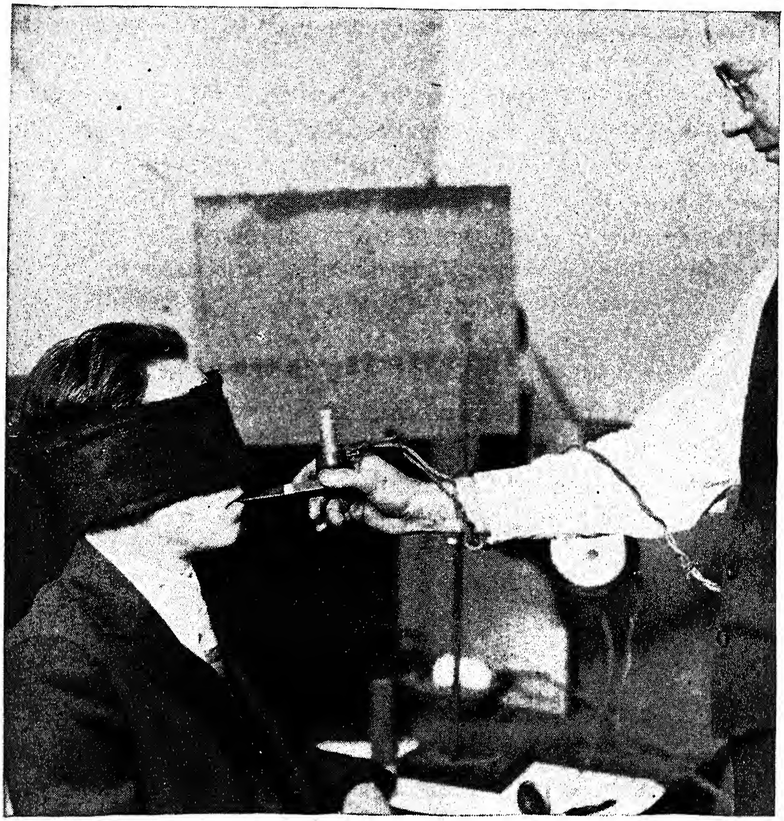


FIG. 108.—Studying the effects of tobacco smoking. To get at the real effect of the tobacco, the experimenter compared performance after a regular smoke with that after a "faked" smoke, where everything had been made identical with the usual smoke except for the absence of tobacco. During the "fake" period the subjects used a pipe similar to the experimental pipe except that instead of tobacco a damp porous cup in the bowl, with an electric coil to warm the air, was used. The experimenter stood nearby smoking real tobacco to provide the proper odor for the session. The subjects were completely deceived and did not suspect that they were not smoking. In this fashion a careful study could be made of the effects of the tobacco while everything else, including the subject's feeling about the matter, was controlled for all the experimental sessions. From C. L. Hull, *Psychol. Monog.*, 1924, vol. 33, whole no. 150, frontispiece. By courtesy of the editor and the author.

and slightly improved the motor performances of most subjects, leaving their perceptual performances unaffected. Double this dose provoked unsteadiness and muscular incoordination in many subjects, and perceptual difficulties in a few In general, the evidence seemed to be that with the smaller dose there was no backswing or loss of efficiency after the drug had worn off, while with larger doses the backswing did appear. The effect of the drug reached its maximum one to four hours after taking, and then passed off gradually. The long-time effect of caffein, or the effect of the habit as a habit, was not investigated.

As in the case of caffein, the effects of *tobacco* are ordinarily interwoven with the effects of suggestion. There is little value in testing for physiological or psychological effects of smoking when the individual is set to expect a standard kind of result, a result in which trembling, emotional instability, and failure of concentration are prominent. For necessary reasons in connection with growth, children are warned against tobacco, and there are relatively few who do not hear of the dire effects upon guinea pigs and the like from the injection of small quantities of pure nicotine. There is practically no value in discussing the physiological effects of nicotine, since it is not nicotine but pyradine, only about one-twentieth as strong, which is brought into contact with the mucous membranes in smoking. The nicotine in the tobacco is decomposed in burning, leaving pyradine present in the smoke. It is true that if given hypodermically there is enough nicotine in a cigar to kill a man, but the problem is to find the effect of the pyradine which actually gets in its work upon the nose and throat membranes.

A careful experimental study of the effects of pipe smoking was made with undergraduate men students. A pipe with an electric coil in the bowl was prepared (Fig. 108); warm, moist air was drawn through the pipe in the usual way, the subjects being blindfolded. The subjects were well deceived regarding the set-up and did not suspect that half of the experimental sessions were "blanks" or "controls," no tobacco smoke having been used. It

is a little surprising that smokers could fail to recognize the difference between warm air and warm tobacco smoke.

The effects of smoking were on the whole slightly unfavorable in the simpler perceptual and motor tasks ordinarily used in this sort of test. It is possible by this technique to show that unsteadiness of hand (cf. Fig. 109) and slight misfiring of delicate eye-hand coordination result from smoking. These results, however, are not large; in several cases they are entirely negligible. Regarding the more complicated mental functions, no measurable result was obtained in either direction A great many writers, executives, and other brain workers who have been interrogated regarding relation of their work to the habit of smoking have testified that imagination is stimulated, thinking speeded, etc. Since most people smoke because they like to smoke, it is doubtful whether these comments can be taken as equivalent to experimental results.

Again, as in the case of caffein, the long-time effects of smoking are not known. Here possibly the questionnaire material from persons like writers, artists, and inventors may be taken slightly more seriously, since in many cases a rhythm of work is established in which smoking plays an easily recognized part, making possible a comparison between years in which the individual smoked and years in which he did not.

Alcohol, even in small quantities, lowers efficiency in most functions.—The results regarding the use of *alcohol* are much clearer. In one particularly careful study, even small doses of alcohol—a few teaspoonfuls—produced in all of the subjects used (including some abstainers, some light drinkers, some heavy drinkers) clear-cut sensory and motor disturbances The report of the subjects as to being stimulated or spurred on by the alcohol cannot be taken at face value, since the measurable effects are in the opposite direction.

It must, however, be remembered that in many cases emotional difficulties, like self-consciousness, self-reproach, awareness of spectators, etc., may be removed by alcohol; and that the removal of these distractions and the sheer "feeling good" which results

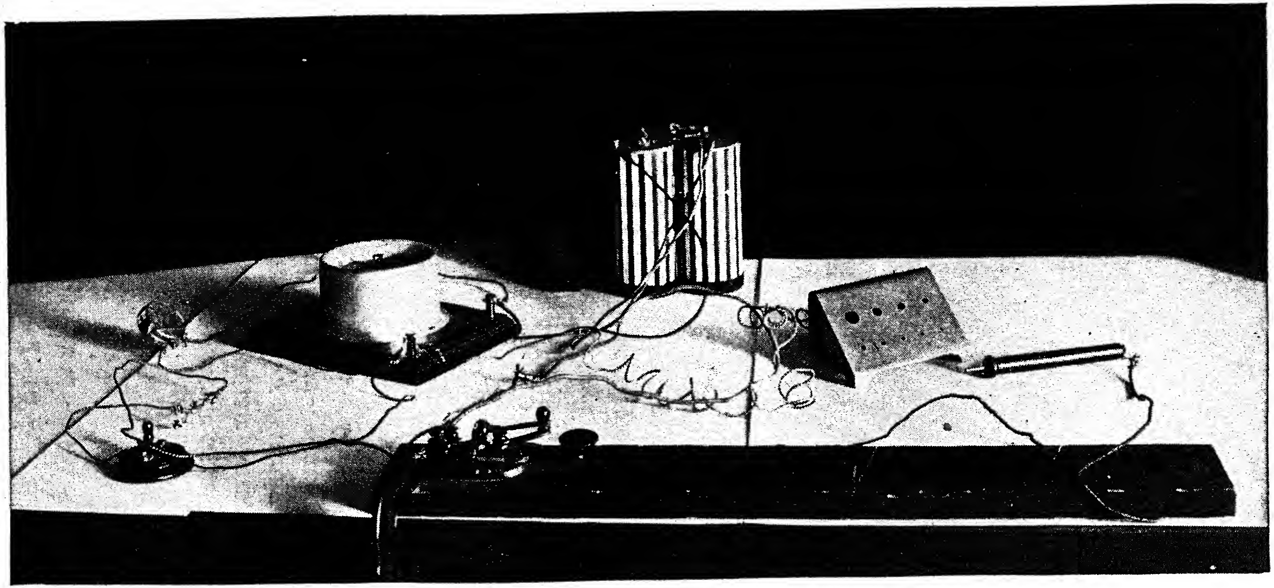


FIG. 109.—Some of the apparatus used by Hull (cf. Fig. 108). Note especially the steadiness board at the right; the subject must hold the metal stylus in the hole, yet keep it from making contact with the sides. Each contact records on an electrical counter (upper left). With the *largest* hole, perfect scores are made by subjects in a normal state; with the *smallest* hole the average subject keeps the counter going at a furious pace. Tobacco increases unsteadiness. When in use, the counter, batteries, buzzer and switch are all concealed from the subject's view by a screen. From C. L. Hull, *Psychol. Monog.*, 1924, vol. 33, whole no. 150, facing p. 54. By courtesy of the editor and the author.

from it may be quite important in relation to certain kinds of mental activity. As we have said, the subject's report that he is doing better than usual under alcoholic stimulation is of no value at all; yet the biography of many a creative artist suggests that for certain individuals in certain situations the psychological effects may really be stimulating. This may, of course, be due physiologically to the removal of inhibition, or blocking, in the same way that a balloon rises when one unties the rope which keeps it to the ground

In summary, then, study of the use of three common drugs has given some measurable results, some favorable and some unfavorable, and varying greatly from one person to another. But the experimental data cover only a small part of the problem. In the case of alcohol, the experimental material, clear-cut though it is on many points, fails to give us what we chiefly need, namely, the picture of intellectual and personality changes occurring over a long time Of course, insanity may result from chronic alcoholism (visual and auditory hallucinations being common features). But our chief interest is not in insanity but in the gradual personality changes which distinguish the lifetime products of different habits and regimens. In regard to such gradual changes, we have, despite the obvious importance of national habits in the matter, rough impressions or prejudices but no definite research findings whatever

One other general fact regarding the psychological effects of drugs should be added A great deal that at first seems to be the *result* of a drug is really the reason for the *use* of the drug Alcoholism, morphine addiction, and cocaine addiction are three common methods of escape for those who have unbearable life situations confronting them Paynter, for example, has found that the great majority of a group of opium addicts are constitutionally normal both physically and mentally in every definable respect. Practically all have begun to use the drug while under the pressure of some emotional situation or (as in the case of physicians in particular) as a way of keeping on with their work after the desperation point in fatigue has been reached Relief is afforded

for the time being But, except possibly in the case of caffein, all the drugs mentioned are habit-forming in the sense that one tends gradually or rapidly to increase the quantity taken.

Health and personality are very important for efficiency, even in routine tasks.—All the principles already stated are subject to large individual differences. Among the most important of all individual differences in work are those relating to health These cannot be exactly measured, especially since they become interwoven with a person's whole behavior. Yet to show how fundamental and important these factors of health and personality may be, we shall cite one such study, offering a comparison of two groups of men employed by the Boston Elevated Company. One group had a *very high*, the other a *very low*, accident record. They were matched for length of service, but study of the two groups and tabulation of the results revealed a considerable number of important differences between them as regards health and adjustment to their work. The problem of accident prevention is partly a question of finding who is relatively free from accidents and who is prone to be a cause of accidents repeatedly. As a result of the systematic study of these figures, it was possible to assign specially safe men to specially hazardous and responsible tasks and thus make a tremendous reduction in the accident rate of the company. It is now generally recognized that accidents are not a matter of particular tasks and particular places and times of day, but that they are in large measure the result of the habits of specific individuals. Through the analysis of these factors of health and personality and paying attention to the danger signs, the accident rate on this company's lines was reduced nearly fifty per cent. The study of general impersonal factors making for efficiency and safety, such as traffic signals, elimination of blind turns and grade crossings, etc., is important, but it evidently needs to be supplemented by investigation of the work habits of each individual.

In the analysis of more complicated skilled tasks, a detailed objective study of the worker's movements and the time these movements consume has been characteristic of contemporary in-

dustry. Fig. 110 shows a typical method of analyzing skilled work and improving its efficiency. The skilled worker has a chance to study a film recording his own movements, and the expert can point out places where waste motion can be eliminated. Sometimes wear and tear results from "speed up"; but such investiga-

FIG. 110.—Elimination of waste in industry. The workman's performance is photographed. Afterwards the film can be run off at greatly reduced speed, and waste or inefficient movements can be noted, improvements recorded, and a more satisfactory routine acquired. Photo courtesy of Allan H. Mogensen and *Factory and Industrial Management.*

tions, if controlled both scientifically and without exploitation of the worker, not only give a momentary gain, but provide a means for adding substantially to the worker's health, efficiency, and satisfaction in his work.

SUMMARY

Fatigue is due largely to "fatigue poisons" in the muscles. These fatigue poisons are carried about in the circulation and may interfere with the functioning of other muscles and of the

nervous system. Mental work also involves some muscular fatigue, but a good deal which passes for fatigue is nervous tension, boredom or worry Sleep is partly a response to physiological wear and tear, but is greatly affected by habit. Among the drugs in common use, alcohol is the only one which has consistently been shown to produce unfavorable psychological results Health and personality are probably more important in relation to efficiency than any other factor considered in the chapter.

REFERENCES

Moss, F. A., *Applications of Psychology*, 1928.
Poffenberger, A T, *Applied Psychology*, 1927
Thorndike, E L., *Educational Psychology*, Vol. III, 1913.
Viteles, M. S., *Industrial Psychology*, 1933.

PROBLEMS

1. Analyze your own work habits, rest habits, and sleep habits In what respects are they adequate for your needs, in what ways inadequate?
2. How could the long-time effects of common drugs be studied? How would you control the effects of suggestion? How would you make up a control group?
3. Make a plan for the systematic reduction of automobile accidents through the study of individual drivers.

CHAPTER XXI

THE DEVELOPMENT OF PERSONALITY

Personality depends on both heredity and environment.—From the discussion of heredity (Chapters II and XIX) and of learning (Chapter XIII) we must work out the way in which personality grows Fundamental *biological dispositions* and their interaction must receive some emphasis; yet all personality differences reflect individual differences in environment. Neither heredity nor environment is adequate by itself for students of child psychology, to whom the day-by-day appearance of new interests and attitudes in the growing child calls for a careful study of both sets of factors The sudden appearance of a new hobby or a new prejudice is as much of a problem to the kindergarten teacher as it is for the parent. The suddenly emerging and often fleeting enthusiasms, whether for a shiny sedan or a box with a funny cover; the strong tendency of one infant to "dance" to music with a swaying of the body while another pats the table rhythmically; the unexpected satisfactions that are now perpetuated and now are crowded out by new ones, cannot be ignored. Nor can we ignore the importance of these for the subsequent development of the growing personality. Against any dogmatic environmentalist we must insist that biological factors determine in large part the *thresholds* for response and therefore the selection of stimuli to which the organism responds Against any dogmatic hereditarian we must similarly urge that the variety of patterns available in the environment determines the kind of development which biological tendencies may show. A rapid sketch of some stages in development, and of some bits of evidence regarding the factors at work in such growth, may be useful, such a sketch will pave the way for a consideration of the problem of measuring

personality traits, and will make it easier to grasp the various theories of personality given in Chapter XXIII.

It is worth while to emphasize constitutional factors in personality which appear too early and in too definite a form to be explained in environmental terms. Some information is derived from a recent study of laughing and smiling in children between eight weeks and one year of age. The children were brought to the laboratory every four weeks during the first year of life, and took

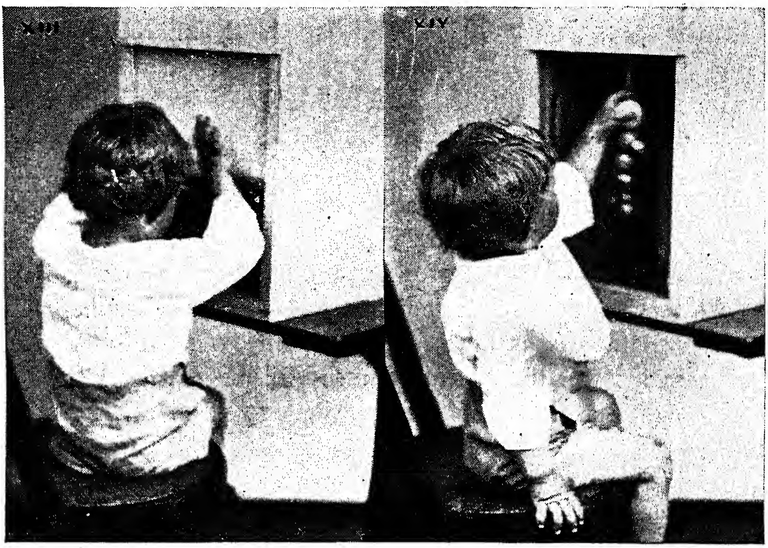


FIG. 111a.

part in a variety of simple games (cf. Figs. 111a and 111b) which bring out laughter and smiles in many babies. In such tendencies to laughter there is apparently great constancy month by month. Despite some variations in health, sleep, and diet, most of the children who could be called definitely jolly in the first experiment were found to be jolly in all subsequent experiments; those who cried easily at one age tended to cry in subsequent months, and the less expressive ones remained so throughout. Granted that many factors, including the personality of the experimenter, cannot be fully measured, this seems to provide a case for the exist-

ence of innate tendencies toward greater or lesser degrees of good-humored responsiveness. Another recent study comparing the same infants who were referred to on page 42 (Fig. 5), reports remarkably constant emotional responses to the examiner during the course of the first two years of life.

There are many similar evidences of constitutional factors in personality, which is natural in view of its relation to the make-up

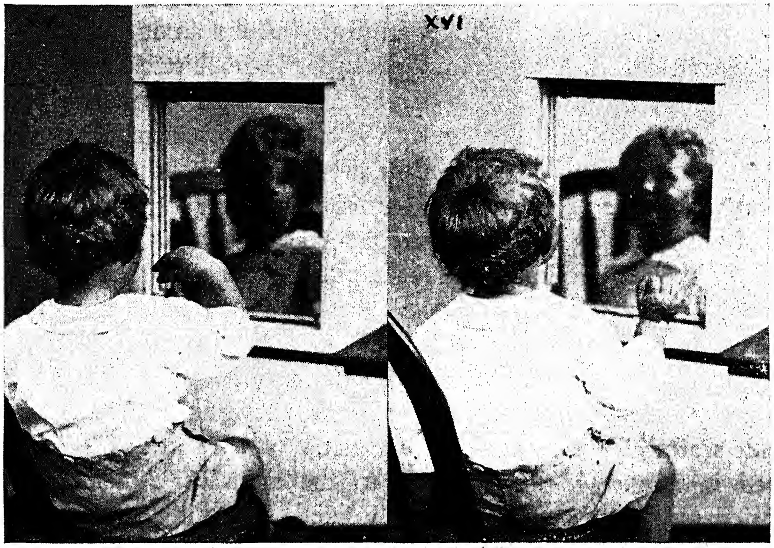


FIG. 111b.—Studying the temperament of children. Young children were studied with respect to individual differences in the tendency to laugh or smile when brought into situations such as this one. These photographs show the laugh and smiling responses when the child discovered his mirror image replacing a toy he had been expecting in the box. R. W. Washburn, *Genet. Psychol. Monog.*, 1929, vol. 6, p. 486. By courtesy of the editor and the author.

of the nervous system, the glands of internal secretion, and the "unstriped" muscles, upon which the emotions partly depend. On the other hand, the student of ethnology warns us to be careful about using these constitutional factors overtime. He points out that among the American Indians there are tribes which are constitutionally almost exactly alike, yet temperamentally very different. One tribe is peaceful and easy-going; another is warlike and excitable. A comparison from more advanced civilizations

yields the same kind of results. People in the South of England and in the North of France seem to have almost exactly the same physical racial composition, yet temperamentally they seem profoundly different. We grow up in a particular kind of society, and even our temperament reflects the prevailing habits and attitudes of this society. It is unlikely that constitutional factors wholly explain the personality differences between the "breezy" Westerner and the "reserved" Bostonian, or the changes in personality "style" that accompany major changes in dress fashion among women—for example, the change from the athletic short-skirted style to the "soft" feminine styles. The degree to which the individual can adapt to these changing patterns, or to the permanent pattern of any social group, is determined by the individual constitution. No doubt each one of us would be an entirely different person if he or she had grown up in a different social environment; but, even so, what the environment can make out of a person depends partly on what he is at birth.

Habit formation is well advanced in the first two or three years of life.—Most stimuli applied to young infants produce a wide scattering of responses, only a few of which can be considered in any way "appropriate" to the stimulus. Among these varied responses, some are quickly fixed, appearing in more and more predictable form, while others rapidly drop out (cf. Fig 64, page 229). Learning involves the rapid elimination of irrelevant responses. In the meantime responses are becoming conditioned to the more striking and powerful stimuli, particularly the social stimuli of the child's world; and higher units are being formed out of all these response elements, which make coherent and workable patterns of behavior From many random responses a relatively small number of *organized patterns* of response are formed Compare, for example, the two hundred or more elements of sound in any newborn infant's babbling with the fifty-odd elements grouped in fixed patterns in the language of two-year-olds who have begun to talk any European language These patterns may always be broken down again, of course, and new organizations formed, but

in general the development is toward stable and complex patterns. The breaking up of the primitive mass response makes possible a number of definite units with which to build patterns; and habits usually represent patterns several stages higher than the simplest conditioned response Interest in manipulating objects, matching colors, following musical rhythms, climbing, playing with coins, tooting horns, etc, is probably dependent in considerable degree upon innate appeals, following upon the maturation of specific responses from the mass of original diffuse responses to varied stimuli (cf page 37).

Yet the things that are liked or disliked, feared, protested against, or loved probably acquire much of their potency as a result of conditioning or association with other stimuli The child who has learned to fear argyrol may be suspicious of all small dark bottles with medicine-dropper stoppers, or even of all small bottles of any size or color; and the child who has seen a parent shudder at the sight of a snake or start with fright at a flash of lightning may show similar "imitative" fears (cf. page 247)

Spontaneity expresses itself through changing habits. Manipulating buttons may be a spontaneous activity, but dressing oneself is an elaborate process composed of many specific learned acts organized into many "higher units." The same is true of such complicated two-year-old activities as climbing stairs, making tunnels in a sand pile, or building a tower. The last-named activities suggest the need for an explanation in terms of something more than habit, namely, *creativity.* The directive tendencies involved in a child's building of a tower are probably not unlike those described in the discussion of imagination and invention (page 360); moreover, spontaneous shifts in attention and in activity are evident in very little children.

As the organism builds up a unified pattern of responses, experience of one's own activities builds up a subjectively unified pattern called "the self."—The gradual appearance of many distinct patterns of motor response (partly through maturation, partly through learning) runs parallel to the breaking down or analysis of the confused world of perception (page 176). For

the student of personality, perhaps the most interesting and important phase of this perceptual development is the gradual differentiation between that part of experience which is "the outside world" and that part which is "oneself." Whether or not this is *entirely* a result of social forces is unknown, but at least the operation of many important social forces is easy to observe The constant use of personal pronouns and proper names forces the child to differentiate between himself and other objects. Meanwhile the conflict between his impulses and the obstacles interposed by other persons works in the same direction. The process is slow; many months are required even to learn the boundaries of the body. In very little children the self is simply the body, and the language of adults directs attention to certain parts of the body, especially the head; but not infrequently an object at some distance, such as a cherished possession like "my dog" or "my doll," may be more closely tied to the concept of self by language and by habit than are some parts of the body, for example, the toes.

Sense of self seems to be definitely localized for most people. Most persons who have been interrogated say that the self is in the chest or head. It is not hard to show that the localization depends on experience Many races have emphasized the viscera and located all conscious processes in the chest or trunk. The renaissance of medicine in the fifteenth and sixteenth centuries revived a Greek tradition that the brain is the seat of mental life; and the doctrine had made such headway that we find in Shakespeare and in the poets of the seventeenth century a wealth of such references to the brain. These are mingled, to be sure, with references to the heart, but with clearer and clearer indication that people were beginning to think of consciousness as "located" in the head Many college students think of the ego as just in front of, or in, or just behind the eyes; many as in the chest; a few as more diffusely localized in the body Localization of the self outside the body, even at some distance, is not unusual. In expansive *delusions*, the self may be literally everywhere.

In relatively few cases have careful observations been made on the genesis of these localizations. One little girl who had just

begun to form the notion of the self located herself in the middle of the right jaw. The experimenter tried to persuade her that she was just as much in the left jaw, just as much in the eyes, throat, and so on, but without success One small region, about as big as a silver dollar, she kept designating as the place she really was This suggests that an adult had touched this spot on some occasion when uttering the child's name. Of course, this association might remain for a long time as a mere matter of *words*—a chance connection between the personal pronoun and one particular spot—before it became anything like an experience of the self. Yet these verbal clues are important. In Piaget's children (page 330) "thought" is at first usually attributed to the mouth; it does not get into the interior of the head for several years, and then, apparently, only because of adult verbal expressions. Dreams remain "out there" and are not put inside the head till the child is about ten. It may be argued that memory images "just naturally" seem to be inside the head, but apparently they were not thus localized until people had learned to think that ideas were in their brains.

The small child cannot sharply distinguish self from not-self; he is therefore called "egocentric."—A royal road to children's perceiving, feeling, and thinking is the study of their language. Most of the language of the two-year-old is a choppy, disjointed naming of objects or acts with little desire to convey meaning to others The two-year-old and even the three-year-old seem to use speech primarily for the fun of talking, for the praise which comes their way as they master new words, as aids in keeping attention directed toward something they want, or simply as part of the total activity pattern which is being carried out

This tendency to use speech for one's own immediate ends without any special reference to the hearer has been called "egocentric." This term is useful in directing attention to the fact that the first purpose of speech in the child's life is not that of communication or even of asking questions. A large number of the first declarative sentences are comments on something the child himself is doing: "I am shutting the door," "I am making a train,"

etc. It is not until the child is nearly three years of age that we have, as a rule, the characteristic expansion of curiosity shown in the "how," "where," and "when" questions, and not until the following year that the "why" questions become dominant There can be no doubt that these information-gathering questions represent a true drift away from egocentrism; but it is not until the sixth year, on the average, that the point of view of the other person is clearly grasped in a way which can be shown in the child's speech. "Egocentric" does not mean "referring to the self." Relatively few of the little child's words refer to himself. What the term egocentric means is that the child's interests dominate his speech and that he has not come to the point of putting himself into anyone else's place or seeing things from anyone else's point of view It would be equally dangerous to conclude that the child is able to set himself in *sharp contrast* to his environment. On the contrary, it is commonplace for a little child to roar with mirth at a joke which he is completely unable to understand, or to scream in terror at a situation which he does not understand but which obviously disturbs his parents. To say that in such cases the child gets the adult's point of view is to attribute to him an extraordinary amount of imagination The writer confesses to have felt some skepticism when he read a German account of a little child bursting into tears when it saw firewood thrown into the fire, lamenting the fate of the "poor firewood"; yet he recently saw exactly the same thing in a twenty-four-months-old boy (no human being was near the flames) It was probably not so much a question of "imagining what the wood felt like" as it was "being in a danger situation" in which "self" and "not-self" had simply never been sharply differentiated. Not to speculate further about matters which cannot be proved, we might look at the objective side of the same facts

Little children often show primitive sympathy.—Children often join in emotional expressions of others about them This is evident in the very beginning when the wails of newborn children set other children crying. Granted that this may be nothing more than distress at the noise near by, it becomes before

long a circular response, similar to those already described on page 247. The hearing of a sound is enough to make the child repeat it, provided the sound is within his own range of responses. As the child listens and observes, he builds up dozens of circular responses which tend to make him repeat over and over again whatever he does or whatever he says. It is, therefore, not surprising that he imitates the simple movements or sounds made in his presence by adults, nor is it surprising that on perceiving an expression of distress in the face of an adult, he responds with similar distress A child of eighteen months or two years may draw back in terror as an adult extends his hand toward a candle flame, provided the child himself has had experience with the pain of a burn. The sight of the adult in such a situation is sufficient to bring about the same responses the child would show if he himself were in that situation. This primitive sympathy response is probably a conditioned response arising from the general similarity of the present situation to some conditioning situation. The parent's hand looks like one's own hand at the time one extended it toward the flame and got the burn Pain and fear having been aroused in the situation of seeing one's own hand in the flame, the response may recur *in any more or less similar situation.*

From the little child's point of view, there is no clear line between "self" and "other." This interpretation is not in conflict with the conditioned-response explanation; it is a supplement to it, and a needed supplement, since it explains why we do not indiscriminately show sympathy with everyone in every situation. As the self is formed, the barriers are set up and distinctions are perceived more clearly The child continues to be identified to some extent with those with whom he is closely connected; they are, in more than a figurative sense, *part of himself*, and they are the last ones from whom he detaches himself. Other persons become detached more and more until most people evoke a neutral or hostile attitude and become less and less capable of arousing our sympathy. Still, in the long run, we do not like to *see* suffering—unless there is strong excitement or desire for revenge

As they grow older, children develop a competitive attitude.—In transition from early to middle childhood a conspicuous step is the development of a competitive attitude, an attitude in which one not only grabs what he wants, but strives for individual success in the eyes of others Three- and four-year-old children confronted by building blocks begin to grasp the idea of building not simply for fun, but to *surpass another.* Even the artificial tasks at which children must compete in the laboratory, such as arithmetic tests, produce all the evidences of a serious desire to win. Practically nothing is done as well alone as in a group doing the same thing, if in both situations the subject is told to do as well as he can

This has been tested by working with large groups of children in schoolrooms. In one case the individual children were classified on a chance basis into three "experimental groups," all, however, remaining in one room: first, a group publicly praised for its good performance in work; second, a group publicly reproved for poor performance; third, a group completely ignored by the experimenter. A fourth group, the control group, worked at the same task, but in a schoolroom in which no praise or reproof was given. The groups were carefully matched for ability to do the task assigned. The praised group did better than the reproved, and the reproved did better than the ignored. The control group fell between the reproved and the ignored. The chief factor here seems to be the prestige or vanity motive. Even competitiveness, though it is nearly universal, differs enormously in degree from child to child.

The near-universality of competitiveness and the huge individual difference in *amount* of competitiveness in children are facts of major importance to be kept in mind in studying other personality developments in childhood, such as are next to be described

So much for the general characteristics of the personalities of little children: conditioned responses, higher units, learning that one is a self, developing new identifications as one learns the boundary of his group, and losing other identifications. Next we

shall consider *individual differences* in the behavior patterns of little children. Unfortunately, we shall not be able to tell to what degree these behavior patterns are determined by heredity; it is probably safer to emphasize environment in most cases. One obvious question relates to differences in the major *interests* or drives

Children have been called "extravert" and "introvert" The extravert directs his energies outward and is absorbed in the things and activities of the world about him The introvert is interested and absorbed in himself; his emotionally aroused energy is devoted to activities going on which are invisible to the outside observer Let us see what experimentation shows about this classification.

A group of fifty boys and girls who ranged between the ages of two and six were put through six experimental situations, in each of which there was an opportunity to show the tendency to direct emotion *outwards* or *inwards.* In one situation, for example, the test measured persistence in sticking to a preference for a toy which the child had once chosen, his degree of introversion was supposed to be measured by the extent of his absorption in the toy that he really wanted The more extraverted the child, the more easily he gave it up and accepted some other toy. In another situation, introversion was measured by the degree of shyness displayed in the presence of the experimenter's offer to play with the child All the experimental results agreed more or less with one another—enough to suggest strongly that there was a common factor, some personality trait running through this battery of tests Moreover, when these children were rated (assigned numerical scores) on extraversion-introversion independently by a group of teachers who had watched them over a long period in the school, the ratings agreed fairly well with the actual experimental behavior. The agreement was not high enough to be used for prediction in the case of any individual child, but it seems high enough to justify the utilization of the concept of extraversion-introversion even in relation to little children

Such a study is by no means unique in its evidence that behind

all the random or inconsistent behavior of children there are certain dispositions or ways of becoming interested, which are really basic moods or attitudes. In recent years experimenters in the pre-school laboratories have repeatedly told us that even in this early period there is a definite "character." One child is consistently dominating, another submissive; one talkative, another reticent; one devoted to group play, another preferring solitude. Such tendencies, whether innate, acquired, or both, are clearly evident at two or three years of age. In one experiment pairs of children were taken to a room to play with a new toy, and the observer, behind a "one-way screen" (so as to be invisible), noted the behavior of each child—grabbing, teasing, sharing, etc. Each child was paired, at a different time, with each of thirteen other children; and three different toys were used for each pair In general, each child's way of meeting the situation seemed reasonably constant throughout. One must always lock for the *reason* for this constancy of behavior. In a recent study by Jack, *submissive* children were taught how to use play materials, and, when put back into the play group, were found to have become *dominating* children. Their behavior was due to experience, not to heredity

The experimental method in the study of the personality and social behavior of children, as just described, has in many cases given brilliant results, but in other cases a certain artificiality is involved in experimentation The child is in an artifical situation and may even be aware of the fact The experimenter may be unable to rule out his own disturbing influence upon the child. One can never be sure that what seems objectively the same situation for two children really is the same for them. One cannot control all the factors which it is essential to control. For all these reasons, it has become imperative to devise reliable and valid techniques for the exact study of child personality when experimentation, in the strict sense of the word, is impossible This has resulted in the development of the "short-sample" technique. The observer first rigidly defines a specific form of behavior which he is to study, such as smiling, crying, temper outbursts, etc.; i e , he must know exactly what he means by a temper outburst and what

signs he is to accept as tokens of it He then chooses time intervals short enough to permit him to record a reasonable number of pluses and a reasonable number of minuses with respect to the behavior in question If, of course, a group of children never showed temper, or if all of them were always in temper, this sort of technique would not be used. When the time interval is rightly chosen, each space in his report will be filled in with a plus if a given child does show the kind of behavior involved in a given period.

The observer will discover how many individuals he can watch and still be absolutely sure to observe everything which comes under the head of the behavior that is being investigated. If the behavior which is to be observed is rigidly enough defined, ten or even twenty children may be observed Different observers make records of this sort. The reliability of the method is first checked by comparing the scores assigned to given children in given play periods by the independent observers. Data recorded with several large groups of children show that observers agree very closely and that children observed over forty days give remarkably consistent results. Such things as nail-biting, disobedience, and temper tantrums stand out as clearly definable habits or character tendencies which constantly recur with a given frequency. The same is true of desirable habits. If a given situation, such as the playground, is the field of operations, and if the children are allowed to make all sorts of contacts with one another, one may say that the individual differences among them, in the kinds of social contacts they make, are reflections of the personalities of the children at the time. This does not in itself throw light on the home or other background factors which may be responsible for these individual differences, but the method can be prolonged backwards, so to speak, to the study of situations influencing the child earlier and earlier in life.

Short-sample methods have been developed for the study of a great variety of other habits. It is, of course, important that the child be *directly* observed Here the "one-way vision screen" may be used, or in some cases, as in the schoolroom or playground, the

observer may be such a fixed and dependable part of the situation as to cause no interference It is, in fact, the child's behavior while in his normal schoolroom or playground setting that one wishes to investigate. For example, the amounts of egocentrism found in different social situations may be most accurately tested in this way. The playground greatly reduces the amount of egocentrism in Piaget's sense of the term (page 449), making literally a different world for the child to respond to

Yet the short-sample methods show clearly, as do the experimental methods, that even a very little child has an individuality, a consistency, which makes him more than a bundle of entirely independent habits.

The degree of children's conformity to ethical codes chiefly reflects their social environment and training.—The character traits which have been most systematically explored in children from a quantitative point of view are honesty, generosity, self-control, and persistence. The results not only are of interest in themselves; they throw much light upon the problem of the study of personality in childhood, the nature of the difficulties to be encountered, and the degree of usefulness likely to be achieved by work in this field.

"**Honesty**" was defined broadly enough to include refusal to cheat, to lie, and to steal The situations in which the child's behavior was studied included some in the classroom, some at party games, and some in athletic contests In no case was there any clue by which the child might recognize that his honesty was being tested, as will be evident from the results. One typical test consisted of an arithmetic test in which the child was allowed to score his own paper. He did not know that the experimenters had recorded his original answers; and he therefore did not realize that whenever, in scoring his paper, he changed his wrong answer to make it conform to the key he betrayed himself. At the party games and in the athletic contests, he could take unfair advantages, the experimenter noting and counting the differences between actual achievement and pretended achievement In all these

studies there was no "reward" except seeming to do well, and no punishment except seeming to do poorly; i e., *competitiveness was the incentive.*

Nine main kinds of honesty situations were used, and hundreds of children participated. These children ranged from the fifth to the eighth grade. There was a steady decrease in cheating from year to year in "group X"; this was a favored group, growing up in good homes and having good schools, good playgrounds, good parks, good summer camps, etc. On the other hand, there was a steady decline in total honesty in "group Z," a semi-slum group in the same city. Thus it appears that total honesty scores bear a clear relation to the social environment. Such considerations would mean that the environment causes a large part (perhaps all) of the differences found between the groups. There is some correlation between honesty and intelligence; and the fact that intelligence is largely hereditary might lead one to say that honesty is therefore partly a constitutional thing, but this is a very superficial way of stating facts. We are certainly not justified in saying that there are innate individual differences which definitely incline a child toward honesty or dishonesty; we are only justified in saying that in the long run a large group of children with better heredity than another large group will probably average somewhat more honest, partly from constitutional but chiefly from environmental causes. In so far as the constitutional factor is present in these tests, it depends on the mere fact that the bright child grasps more clearly what the test is about, has been able to pick up better coordinated habits of resistance to temptation, and, putting the two together, sees that the temptation is out of line with what he wants The dull child has picked up less orderly habits about honesty; he thinks in terms of the credit of doing well on the test or in the competition, and not in terms of standards or of the humiliation which might possibly result from getting caught at cheating. However, this is not the only social factor at work The suggestibility of the children is important in relation to their honesty. A good deal of the cheating was shown to be due to the cheating going on in the child's immediate neighbor-

hood. The factor of classroom morale is tremendously high; one does as one's group does.

Another result appearing from comparison of the nine different honesty tests is the rather low positive agreement from one test to another. A knowledge of the child's score in one test permits but little by way of prediction regarding his scores in the other tests. If, however, five of the tests are compared with the other four, the "chance factors," the factors other than honesty which enter into the tests, tend to cancel out more or less, and the prediction becomes much better. Any five tests will predict the other four *fairly* well. This means that there is a definite general honesty factor running through all nine tests; and this is probably the standard of honesty, or the group of verbal or other internal controls, used by the subject in holding himself to his social obligations. We should expect that this standard would become better and better consolidated as the child grows older in a favored community; and this is exactly what happens. In the favored group the total honesty scores not only went higher and higher; the agreement between scores on the nine tests went up and up The degree of "consistency" was increasing, pointing to the actual *formation of character.* The social forces acting upon these children are actually making for a closer relation between different kinds of activities, and are binding certain activities together. The children are learning what the adult standard of honesty is, and are learning to respect this standard. Such consistency as they show is evidently due to social standards, and social pressures which work toward these standards, rather than to inborn tendencies to be honest or dishonest.

Five tests of generosity were used by these same experimenters One of the tests involved working for the credit of the whole class in a competition in which classes were pitted against one another, the scores being compared with those made by the same children when each was working for himself Another test involved giving up, for the use of poor children, materials from a school kit containing pencils, erasers, and blotters. A third test involved coming early to school to make up scrapbooks for sick

children in hospitals The same general plan of studying the results was followed. Again, though scores on each test considered separately agreed only moderately with those from other tests, any three of them permitted some prediction about the others, suggesting a *general factor* of generosity which ran through all five.

Tests of persistence and inhibition included those in which dull tasks were carried through despite interesting distractions, and in which there was "grinning and bearing" of tedious situations out of which the child could slip if he wished.

When all four of these character traits were compared, it was found that there was a general character factor which ran through all of them, each trait being positively related to the others to some degree. This factor of general character is related to intelligence to some degree, but there is a long list of factors which seem to be of importance. The child's socio-economic status, religion, suggestibility—even his nervous habits, such as nail-biting—seem to be part of the picture We cannot always be sure of what is cause and what is effect when we find evidence that the child of "undesirable" character also shows certain signs of mental difficulty and maladjustment. Of all the background factors of a given child, the one which seems most important is the type of neighborhood from which he comes. All these experiments show children being molded in the attitude of the family, play group, school group, etc., to which they belong, their personalities reflecting the characteristics of those about them.

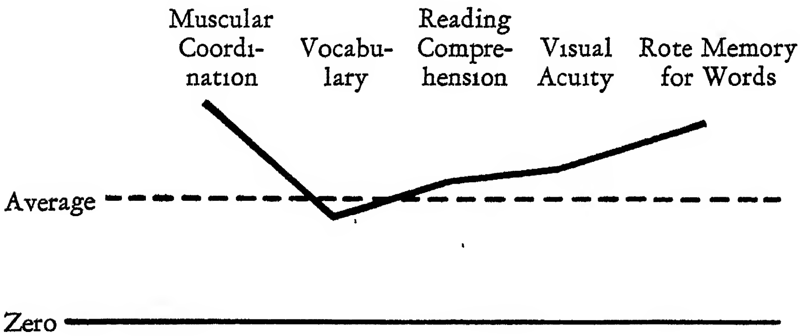
The modern "case study" attempts to make the study of personality into a sort of scientific biography.—The art of biography is about as old as the science of psychology. That is to say, the definite working out of a plan for the presentation of the course of the life of a man or woman was achieved by the Greeks at about the same time that they conceived the notion of a systematic study of the mind. They raised a number of problems and settled a number of questions of technique which have made all subsequent biography indebted to them. These literary psy-

chologists, who told the story of individual lives, sought to accomplish two tasks: first, to discover the laws of character formation; second, to describe the unique characteristics which made a particular individual unmistakably himself and distinct from every other individual who ever lived. The first problem, that of finding the universal laws which govern all personality growth, is a task like that of finding general laws in anything else. The same spirit which moved the Greeks to try to find the laws which the planets obeyed led them to try to formulate a science of character. In its technically psychological sense this was what Plato and Aristotle did; but in its literary sense it was done most brilliantly by Theophrastus, who undertook to find the essence of character, the peculiar way in which character traits hang together in such a way as to create a sort of "pure type" which could be recognized anywhere He describes, for example, "the flatterer," each of whose fawning insincerities is so interwoven with the rest that the account makes a coherent whole. The account rings true. One almost feels as if one were reading a demonstration in Euclid, each part is so perfectly fitted to the rest.

On the other hand, a great many of the biographers deliberately refuse to be drawn into this tendency toward abstraction. The essence of a man, they hold, is not the fact that he portrays this or that general law of character formation, but rather the peculiar individuality which makes him unique. This kind of literary biography would have no more interest in the laws of character formation as such than you who are fond of your dog have in the abstract zoological principles which the dog's breath and heart action represent. This literary endeavor toward the description of the unique is brilliantly exemplified in Xenophon's account of the character of Cyrus the Younger, written about 400 B.C., and said to be the first character sketch ever thoroughly worked out.

Modern psychology has been greatly influenced by and is very much interested in both these kinds of biography. Both, in fact, have an important place in the personality study made by the present-day clinical psychologist. By means of various measuring

sticks which psychology has devised, such as tests for memory, vocabulary, manual skill, social and emotional attitudes, and so on, the psychologist undertakes to find just how much of each characteristic the person has at a given age. He gives careful tests over and over again to the same child as he grows older. Meanwhile the social surroundings of the child are observed in order to form an idea of the degree to which growth depends on social factors and education. The individual is compared with many others who take the same test at the same age; the general rate at which these tendencies develop is studied and an effort made to find what degree of prediction the tests permit as to the traits the individual will show as an adult. In this way one can construct at any given age a "profile" or "psychograph" like the following:



Here one can see at a glance how much of each trait a given individual has If the dotted horizontal line represents the average for that age and sex in that community, one can quickly tell that the individual is highly endowed in respect to muscular coordination, rather poorly equipped in vocabulary, and yet, nevertheless, slightly above average in comprehension of ordinary reading This, of course, does not tell us to what extent these traits were determined by heredity, but it gives us a preliminary picture of the individual as we are going to study him year by year. Remembering that we are comparing him with others who are also growing up and developing in these functions, we can see just what is happening to him to make him nearer to, or further

from, the average of his group. If, for example, there is a bad balance, so that he is far ahead of his group in some respects and far behind in others, we can make an intensive study of this and find out whether it is causing any important distortion or handicap in the development of his social relations, such as his friendships. Sometimes in using a profile like the above we are interested not simply in single traits but in groups of traits; for example, the scores for tapping, for muscular coördination, and for steadiness in standing may all be considered together in case we want to see whether there is consistent evidence of that form of nervousness which would cause a gross inability to maintain steady muscular control. In the same way, though a small vocabulary might not prove anything in itself, it might, in conjunction with poor ability to form rote connections between words and to read and understand passages even when made up of words which the child can define, point in a general way toward a clumsiness or lack of skill in handling words.

In all this the reader will recognize the theory of character that Theophrastus held, namely, that if traits are studied in their interrelation they will reveal *general laws* about the growth of personality. We need, of course, a great many such profiles and we need to follow a large number of children over many years; but the method has thoroughly justified itself and it suggests that we can make a scientific study of the process of personality growth Most important of all, the task involved here is to measure things which are dynamically related to the everyday activity of the child A thing like muscular coordination may be unimportant in some situations; but if it makes the difference between making the basketball team and failing miserably at a critical moment, it is worth studying Traits like self-control, ability to resist temptation to cheat, and willingness to give up pleasure for the sake of other people, are well worth measuring, even though we know that these things fluctuate greatly and that no single test can tell the whole story.

The present trend in psychology is much more toward measuring fundamental and significant traits and finding the interrelation

between them than it is toward chopping off a single habit and making a study of the details of the situation in which this one habit emerges. We might learn *something* from the latter procedure, but social situations change so fast that we can be quite sure that what we should find in such a case would never really recur again. In other words, we need to see the personality as a whole in order to have a context by which to understand any given part.

The other kind of biography (Xenophon's kind, mentioned above) is illustrated at its best by the careful case studies made in the modern child guidance movement. The procedure owes a good deal to psychiatry and to the methods of the social worker The movement has been greatly colored by many other trends in American life, and has only recently been given a prominent place in psychology

The case method, as used in a psychological clinic or child guidance clinic in a large city, consists of the following: When a child has in some way gotten into serious trouble or encountered serious difficulty, and if the parents are unable to handle the situation, he may be taken to one of the clinics, where his parents explain the whole trouble A social worker obtains the facts of the case from parents, teachers, and all who have had an opportunity to watch the child in various social situations, such as playground, school and home. She also talks with the child, to get his own story of the trouble, and, in addition, as complete a picture as possible of his attitudes and the basis for difficulties A physician gives the child a physical examination and a psychologist gives a standard verbal intelligence test and a performance test. As a rule educational tests are also given, to see how the child stands with respect to school accomplishments. The psychologist also notices and records many details of the child's personality, such as talkativeness, shyness, contrariness, good nature, and so on.

After these data are all assembled, the psychiatrist in charge makes friends with the child, gets the child's point of view about his own trouble, and tries to see how far all the different sources

of information agree. Later, at a staff conference, he and his aides talk over the matter and make a tentative guess as to the explanation of the trouble It may, of course, be anything from adenoids to a bad placement in school. It may be an inherited mental defect. It may be a perfectly normal emotional reaction to a bullying older brother, or it may be a worry over a conflict between his parents On the basis of the tentative decision, recommendations are made to the teacher, or the parents, or other adults in close contact with the child. The child comes back fairly frequently, usually every few weeks, and the degree of success of the plan is thus constantly checked. These studies may continue for years where the case is persistent or chronic, as, for example, when it is due to some inherited defect; data may be gathered from early childhood on into adult life As a rule, however, we have to rely on rather short histories because either the child gets over his difficulty or the parents become discouraged and withdraw him. On the average, these records give us cross-sections of about eighteen months to three years of the child's life. If one has a large number of them, he may be able to see certain general trends which run through the life history of children Consider, for example, such a common thing as the origin of an inferiority feeling, or of shyness, or of a tendency to outbursts of temper When one can actually see these things in the process of formation and see how they influence the whole texture of personality as they find more and more modes of expression, he is able to get a great deal of insight into the nature of personality and the laws of its development The case study, in other words, gives a certain broad perspective of personality growth which could not be obtained from short-time observations such as we get in most experimental work.

One of the most urgent tasks of biographical psychology is the combining of these two distinct methods They seem on the surface to be opposed to each other; yet, as we have seen, the study of many individual histories suggests the study of general principles. Regarded a little more closely, the problem seems to

come to this. How can the details of a case history, which have to be understood in connection with the *particular* child's life, throw any light upon *general laws* or principles in which we are concerned with broad "impersonal" problems with which science deals?

The answer is that in the biographical kind of psychology one has to see a large number of factors at once, and must study all possible combinations in order to determine just what factors in the context of a given symptom really are important Suppose, for example, extreme bashfulness is found in a large number of children. Suppose that in a hundred such children forty are found to be very dependent on their mothers. One would have tended, years ago, to say that the habit was a reflection of the dependence on the mother. The psychologist has been taught by bitter experience that he must not draw such conclusions unless he has a control group In this case, for example, he would need a hundred children who are comparable with the other hundred in general social surroundings and in such important things as age and intelligence, but are *free from* bashfulness. It may turn out that this control group, which does not have any bashful children, will show the same proportion of children who are very dependent on their mothers. That is to say, it may be something else in the social setting which caused the bashfulness, or it may be a combination of many factors. The use of a control group is but one of many ways of recognizing the fact that almost every personality trait arises from many causes. Having once achieved this point of view, one is inclined to feel that the study of a large number of personality records, despite the uniqueness of any individual, does give genuine principles or laws comparable to the laws one would expect to find in any other complicated subject matter. In other words, the opposition between the two methods of biography disappears if one takes both methods at their best. The uniqueness of the individual will, of course, remain after all is said and done, for the individual does not have to be unique *in every respect*. In fact, he is not at all unique in isolated

respects. The thing that is unique about him is *the particular combination and organization of the particular traits.*

Personality is organized largely in terms of internal control, to which we give the name "will."—We mentioned the development of *character*—but what is character? A set of standards, of course, and an inner technique for holding to these standards, but what *is* the technique? Usually we say that it is "the will." A newborn infant wails and squirms; he is at the mercy of his environment. If a three-year-old wails for a trivial reason we treat him like a small baby, commenting on his lack of self-control and insisting that he develop his *will*. Will thus seems to be something developed as the child develops; it involves inhibition of reflex or impulsive acts; it can be cultivated by practice. All this suggests a preliminary definition in terms of an *internal regulatory mechanism.* Remembering that internal regulatory mechanisms were found, in the case of thought and imagination, to be actively allied to language, one might suspect that will would be allied to the building up of inner language habits. At any rate, we shall try this as a hypothesis.

How may an activity be reinforced by means of inner resources? Two factors are important in the mobilization of the self in the battle: the one, the throwing into the scale-pan of what McDougall calls the "*self-regarding sentiment*"; the other, the use made in most acts of will of *verbal symbols for conduct.* The group of events leading to the development of the "self-regarding sentiment" includes a series of experiences relating to prestige and to the goals or standards pursued by the individual which may be drawn upon in holding him to a difficult performance. Thus, as to the children whose degree of honesty was reported on page 456, it may reasonably be said that the fact of temptation tended to arouse a considerable portion of the entire behavior system or personality of the individual—he is "not the kind of a person who would cheat." This leads directly to a consideration of our second criterion, namely, the fact that in throwing in extra effort, one of the chief mechanisms called into play is a verbal pattern

which symbolizes and reinforces adjustments characteristic of a given standard or ideal. One may sometimes actually prevent flinching in the dentist's chair by what one says to oneself about not being a coward. The bracing of hands or feet would here represent the physiological response which needs to be supported by appropriate internal verbal patterns, acting to condition the more precise and effective movements involved in maintaining a fixed posture. The fact that mentally defective persons can resist interference and can persist in pursuing a simple immediate goal—but are notoriously impulsive and lacking in the normal adult kind of will—means simply that they have built up less effective standards and less adequate verbal control. *The strength of a person's will is partly a matter of the adequacy of internal verbal control when intense disturbing stimuli or baffling obstacles are presented.* A Spartan or an Iroquois Indian learned almost as a matter of course to endure pain without betraying the slightest trace of suffering, but in other spheres of life showed an impetuosity quite out of keeping with the specific habits of self-control A man may have any degree of self-control or any amount of will in a particular situation without having it in other situations.

The reaction-time experiment tests the swiftest voluntary response to a stimulus.—To study the will experimentally, we turn to a familiar psychological experiment which seems well adapted for investigation of voluntary activity, namely, the "reaction-time" experiment. We may ask the subject to fixate a small circular hole in an exposure apparatus and to place his finger on a telegraph key, instructing him to lift the hand from the key the instant a light appears behind the hole; or we may tell him to make a similar response when he hears the click of a key, or as soon as he is aware of a light touch or a faint odor or taste (Fig. 112). Because of the nature of the experiment, the subject must be *instructed* as to the general character of the stimulus presented. This is one of many ways in which the response in this experiment differs from the simple reflex Practice must be continued for at least several dozen trials, or preferably for several

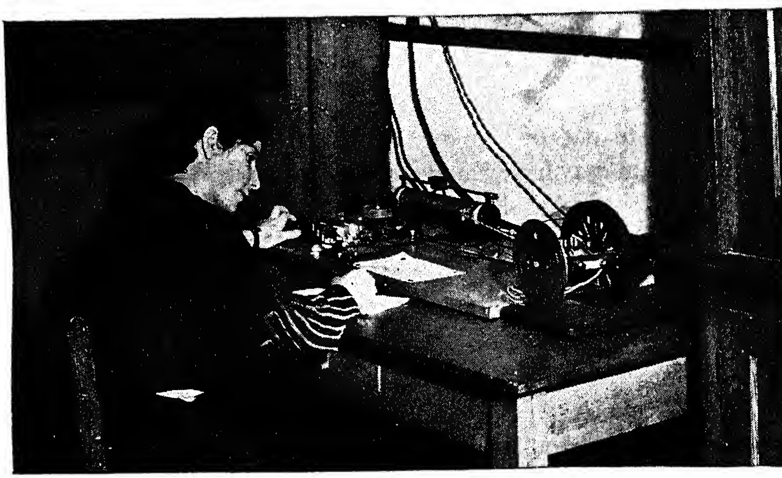


FIG. 112.—The *reaction-time* experiment. In the study of voluntary action, the time needed to respond to stimuli under different conditions has proved a fruitful approach. The upper figure shows the subject in such a study prepared to respond by pressing on either one of the two telegraph keys in accordance with a prearranged code. Below is the experimenter, in another room of the building, with a keyboard which permits her to present any one of a variety of stimuli to the subject, and a device which shows the time taken to make the reaction (depending on a motor which starts when the stimulus is given and stops when the subject responds). This device is a Dunlap chronoscope which gives readings convertible into thousandths of a second.

hundred, before the subject can be said to have adjusted perfectly to his task. The criterion of this adjustment is the amount of the subject's variation from trial to trial

The reaction-time experiment is the best simple standard procedure by which to measure the speed of voluntary action At the same time, it helps to show how hard it is to tell *just what is voluntary*. The response of a trained subject seems to be the quickest response he can make; the speed of response may appear to be at its *maximum* and the subject at his "physiological limit" He is now warned that any response slower than 150 one-thousandths of a second will be immediately penalized by a painful electrical shock, and he is shown what this means His supposed "physiological limit" immediately becomes shorter by 20 one-thousandths of a second. What was "involuntary" is thus really under some degree of voluntary control.

While "prospecting" in the region of the will, it is worth while to note that *as the subject awaits the stimulus his fingers show tension*. The reaction is touched off as if by a hair trigger. Faulty reactions—made when the stimulus has not been presented at all—are common, and point to the fact that the muscles are in a keyed-up state, a state of readiness which makes the carrying out of the voluntary act quick and easy This keyed-up condition is measured by recording the tension on a spring or on a rubber diaphragm. The tension, and the fact of faulty reactions, contribute something definite to the theory of the will. If through too much tension one can make the response "without meaning to," this fact throws light on life situations in which under tension we discover that we have said or done something which we certainly did not "mean." Our muscles may be prepared for an act and this may lead to the act without our realizing it.

The reaction-time set-up has also been used to measure discrimination and choice time (cf. page 217). When the subject is instructed to withdraw his hand from the telegraph key if a red light appears but not if a green light appears, this discrimination reaction takes longer than the simple reaction Another experiment requires the subject to place each hand on a telegraph key, and

to react with the right hand if he sees one stimulus and with the left hand if he sees the other stimulus. The characteristic "choice" times here run higher than the "discrimination times." In one reaction-time experiment subjects were trained to use all ten fingers, each with its telegraph key, and to lift the appropriate finger for each color shown. After long training, some subjects attained such a high level of efficiency that only about three-fifths of a second was needed for the response. Much of the training here was on the perceptual rather than the motor side, and the training period may reasonably be regarded as a period for organizing particular response patterns in relation to stimuli which are to be shown (cf. page 240).

Even in such complicated experiments we are dealing with *voluntary response.* Experience as a subject in such experiments helps one to learn something of the intricacy of what we call an "act of will." For some subjects one permanent element of the discrimination and choice experiments is the use of verbal symbols uttered to oneself to guarantee prompt and errorless responses. The act of will (at least until the whole procedure has been mechanized) shows itself in verbal and other internal symbolic controls, manipulated so as to prevent the external stimulus from precipitating an overt response except in the determined direction. Hudgins and Hunter have recently worked out a theory of the will in terms of such internal control, and have conducted a most ingenious experiment to test the theory, as described in the next paragraph.

It is possible to acquire voluntary control over "involuntary" muscles.—A bright light was flashed into the eye simultaneously with the ringing of a bell. After many repetitions, the contraction of the pupil was aroused by the sound of the bell. From this point onwards, subjects were instructed to squeeze a dynamometer which, upon closing, caused the ringing of the bell and the flashing of the light into the eye. Then the subject was instructed to repeat the word "contract" when the experimenter said it, and while making the muscular response. In time the situation, squeezing the dynamometer (so as to flash the light)

plus saying "contract," became an adequate stimulus for eliciting contraction of the pupil. Subjects then discontinued use of the dynamometer and simply said the word "contract," first in a whisper, later silently. The response, having been established under these conditions, could now be elicited by the *silent inner utterance of the word "contract" alone* (Fig. 113). In

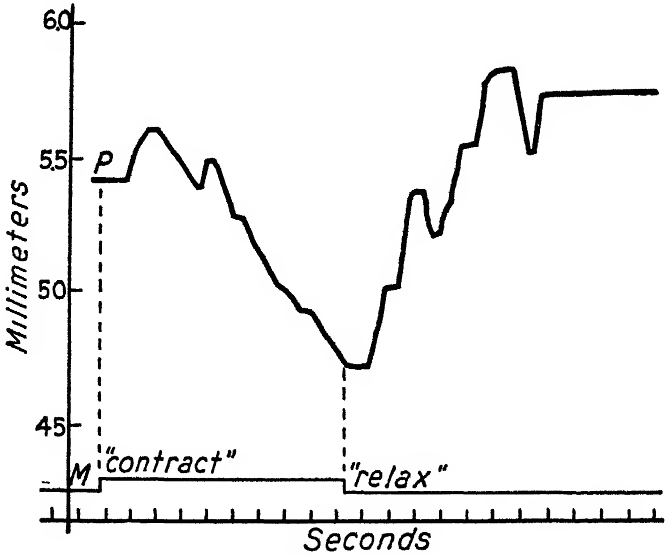


FIG. 113.—Record from an experiment bringing an "involuntary" muscle response under voluntary control. Normally, the adjustment of the size of the pupil of the eye is not under conscious control, yet, by a series of conditionings, a subject was able to cause the pupil to contract by silently saying "contract" and to dilate when "relax" was said in a similar fashion The record, *P*, shows the size of the pupil opening following the thinking of the words Note that after "contract" there was a narrowing of the pupil, and after "relax" a widening of it. From C V Hudgins, *J. Gen Psychol*, 1933, vol. 8, p. 30 By courtesy of the editor and the author

exactly the same way the inner saying of the word "relax" produced a pupillary *dilation* (after a training series with reduction of light). The subject's control of his own pupillary response was thus achieved through inner speech The experimenters point out that the internal control over a muscular response is what we ordinarily mean by volition. As a check, experiments were per-

formed which showed that prior to training inner speech caused *dilation* (the sensory reflex). Training toward contraction reversed this effect and training toward dilation increased it. Most of the subjects were ignorant of the purpose of the experiment. Older views that the conditioned response is really a voluntary response seem justified, if by this we mean merely that *conditioning to internal changes* is the thing with which we are ordinarily dealing when we speak of volition. Though the experimenters do not make the point, it seems legitimate to add that any fragment of the conditioning situation, even the imagining of the light, or an auditory image of the word "contract," might under some circumstances conceivably produce the pupillary response in the same way that the visual and auditory stimuli do.

In conclusion, we may say that there are indications that the will is a kind of acquired control. It can control even the "involuntary" processes in a manner to be expected from the psychology of learning; moreover, everything affecting the ability to acquire internal symbols is important in a theory of the will. A reasonable working hypothesis is that the will is a name for the integrating processes themselves, when this integration is contrasted with reflex activity which would appear in an animal or a child dominated by a strong stimulus. Since language plays a prominent part in the acquisition of personal goals or standards, it is natural to regard the growth of the will as dependent in considerable degree upon language; but any symbolic process by which the individual's impulses are directed, or his energies marshaled, is a voluntary process.

SUMMARY

The growth of personality depends on maturation and on learning. Mass action gives place to specific reflex acts, and the latter are knit together by learning, even during the first months of life Thus a new organization and unity in behavior are achieved Corresponding to this objective unity is the subjective unity which

we call the self The middle childhood period is characterized by the development of the competitive attitude, by the acceptance of the ethical standards of the group, and by many other ways of conforming to customary social conduct *Individual differences* in personality are evident throughout this whole period; we know more about the social reasons for these differences than we do about the biological reasons, but both factors cooperate. The case study is the most complete method of studying the growth of personality in the light of heredity, home surroundings, school life, playmates, etc. The will is an integrating principle in personality which appears to be based on conditioned response to inner symbols.

REFERENCES

Gesell, A , *Infancy and Human Growth*, 1928.

Hartshorne, H., May, M. A., and Shuttleworth, F. K , *Studies in the Organization of Character*, 1930.

McDougall, W , *Outline of Psychology*, 1923, Chapter XVII

Murchison, C (Ed), *Handbook of Child Psychology* (2nd ed.), 1933.

Piaget, J., *The Child's Conception of the World*, 1929

Thomas, W I , and Thomas, D S., *The Child in America*, 1928

PROBLEMS

1. What information about an individual would you consider necessary for a good case history? Make a brief outline that might be used as a guide for writing case histories
2. Put down all the memories that you can recall from your first five years, add all the information that you can collect from your parents or older brothers and sisters about your early development, interests, habits, emotional tendencies, etc How many of the basic trends that characterize your personality now were discernible in any form during these first years? Have any major interests or emotional trends of that period disappeared? If so, were they primarily of the sort common to all children of that age period, or were they peculiarly characteristic of your own individual personality?
3. On the basis of the principles of personality growth that you have learned so far, and your analysis of your own development and that of other persons you know intimately, outline the major hypotheses that you would like to formulate for the rearing of children

CHAPTER XXII

THE MEASUREMENT OF PERSONALITY

Many differences between personalities can be stated in terms of degree, i.e., they can be measured.—In the study of the personality of the little child we found need for quantitative methods. It was noted there that experimental methods often have to be supplemented by other kinds of measurement which do not so rigorously control the conditions under which behavior appears. As the child grows and becomes more and more unwilling to be observed, living a larger and larger part of his life in his world of symbols (inner speech and imagery), he is harder and harder to experiment upon; and when he nears maturity he is, despite our pressing need for reliable information, an "inaccessible" subject of inquiry. How are we to gauge and appraise personalities; how may they be compared with one another; how may the differences between personalities be stated in exact form?

Character and personality cannot be read "at sight," but must be carefully studied.—Legitimate interest exists in the question whether we can, in any sense, read character or personality "at sight," that is, by interpretation of the face, voice, posture, handwriting, etc. For the most part, psychologists have not taken any of these claims seriously because nearly all the character-reading systems savor a good deal of phrenology and palmistry, and they cannot see why anatomical traits should have much to do with mental traits. Of course, it is easy to make assertions of all sorts about the relation between bodily traits and mental traits, and then find cases which seem to offer brilliant proofs. For the most part, the authors of such books declare that a certain trait is accompanied by some physical characteristic of a

particular part of the body; they show why "it must be so," but not that it *is* so. On the other hand, a number of psychologists have, in recent years, gone to the trouble of testing out theories of this sort on a large scale. One elaborate "character-reading method" has been tested, in great detail, by thousands of quantitative studies. The results showed that this "method" was worthless.

Of course, some kinds of observation of the body tell us something about personality The reader will recall that studies of muscular tonus, blood pressure, etc, have thrown light on mental activity; and we know something about the ways in which the muscles of the face contract during emotional states (page 89). The study of posture, mannerisms, and many little details of physical conduct may be of great service. The person who has long studied a particular kind of expression can make the best interpretation of it. The actor knows how to portray the kinds of emotions that it is possible to portray, and there are few actors, if any, who are not to some degree specialists in depicting special kinds of emotions which are typical of certain personalities. The animal trainer knows how to interpret emotions in his animal which others might grossly misinterpret. In general, the value of character reading, in the sense of *studying and learning to interpret emotional expression*, must be emphasized But this is entirely distinct from any kind of character reading which depends upon anatomical characteristics. Selecting employees because their faces are round, and hence supposedly indicate a certain characteristic, would be as absurd as selecting them because their eyes were dark.

The case of handwriting lies between the two groups of cases considered. It is, in a sense, a matter of expressive movement, but it is also in a sense dependent upon the anatomy of the hand, wrist, and forearm. There seem to be some real sex differences in handwriting. This may be due partly to the ideals of a masculine and a feminine handwriting which boys and girls respectively imitate. The fact that handwriting experts can tell us a good deal about the physical basis for the movements which are made means

that there is some deep-seated and not merely accidental cause for the person's handwriting; on the other hand, there are certain obviously accidental factors, such as the particular type of writing which a particular schoolmaster may have insisted on There may be some differences which are of real significance for psychology. The recent work of Allport and Vernon has shown that handwriting may be matched with personality sketches to a consistently better degree than could be obtained by sheer guessing For example, college students can guess, a little better than mere luck would allow, which one of ten handwriting specimens belongs to the right man in a group of ten whose personalities are described in a short paragraph. These, and similar studies going on in Germany, justify the expectation that the study of handwriting will prove valuable in psychology As yet, however, the whole matter is rather obscure; and although the individual guesses are better than chance, they are not very much better; they do not help us much toward an understanding of the relation of personality to these expressive movements. Handwriting experts consistently do considerably better than college students in sizing up personal traits from handwriting, but they are unable to explain clearly to us how they achieve their results.

Since we cannot "read character at sight," it is important to see how we really can "read" and measure personality and character. We shall begin naively by considering all the socially accepted names for "traits" (shyness, aggressiveness, obstinacy, originality, etc) as in some degree indicative of traits which are socially significant and worth studying, *as they are observed by acquaintances,* even without objective measurement. Whether these traits are to be considered just habits, or *groups* of habits, or as partly or wholly *constitutional* affairs, is a question best postponed until we have surveyed the methods and concepts in use for studying them.

Those who know a person well can rate him fairly reliably on behavior which they have observed.—There are numerous characteristics of persons which we cannot really measure. There

are no adequate experimental techniques by which to test a person's tact, conceitedness, submissiveness, or changeability of mood. In attempting to treat such characteristics as accurately as possible, we resort to devices in which measurement depends upon some form of estimation. If the estimation is made in terms of checking various numbers, as in the following,

1	2	3	4	5
Very aggressive	Aggressive	Moderately aggressive	Retiring	Shy

or

Degree of Aggressiveness

1	2	3	4	5
Great	Large	Average	Small	Slight

we have a sort of *rating scale.* Individuals may rate others whom they know, or in special cases they may rate themselves. Data collected in this way must be carefully checked by various techniques. One way of checking is to demand the identical ratings from the same raters a month or two later and to see how consistent the raters' performances are in judging the same people Another method is to compare a large number of independent judges' ratings with one another. The third method is to compare ratings on supposedly identical "traits," the descriptions of which are phrased in different ways—to see, for example, whether a person who is rated high in conceitedness is rated low in humility. On the basis of the work done, it may safely be said that judges can agree with one another fairly well about the traits shown where the person's actions are such that his associates can *see* the trait in action Thus, traits like aggressiveness and submissiveness can be rated rather well Other traits, dependent more upon inner activities such as purposes and ideas, cannot be rated well enough to be worth the time. Even the judgments of a sense of humor show a variation from one rater to another which makes us wonder to what extent we are merely collecting data in relation to the psychology of the raters. There are various ways of eliminating the usual errors which come into ratings. One is to ask judgments from at least three independent raters who know the sub-

ject well. Another is to try out raters with reference to various traits and find out the traits upon which these particular raters can do a consistent job

Since a rating is almost never used if we already have a good objective way of measuring the trait, ratings are not to be classified as reliable and accurate "measurements." But their value can be increased by the use of objective samples, compare Fig. 62 (page 224).

The psychology of rating is itself interesting in pointing to "stereotypes" or "pictures in the heads" of the raters. Eleven photographs from the *Boston Herald* showing people who had featured in the day's news were shown to college students, with instructions to assign to these people various labels, such as financier, United States Senator, bootlegger, Bolshevik, journalist. The students showed an extraordinary amount of agreement among themselves, both when they were right and when they were wrong. About half the students thought that the individual with the Vandyke beard was the United States Senator; actually he was a Soviet envoy. When the students were asked to rate the men on "craftiness," they showed consistent tendencies to rate them in accordance with stereotyped notions of what financiers, journalists, etc., are like. One group of students was then given the true identities, and a second group was given false identities. When the pictures were rated again, the raters showed a shift toward our common stereotypes; for example, those in the misinformed group assigned an increased amount of craftiness to the man they were told was the Bolshevik. Ratings are, then, a device for studying the degree to which common biases and prejudices appear in judgments of people and things. This second use of ratings may be of value even when more accurate methods exist for personality measurement.

In some cases a person may give reliable information about himself through a questionnaire.—Another crude but necessary device for collecting quantitative information is the questionnaire, which consists of a series of questions relating to one central problem. The emotional characteristics of individuals

or their attitudes toward other people are the themes most frequently studied by those who use this method. In such problems as research on attitude toward other races or members of other religious groups, questionnaires are often of value. They are subject to "sampling errors," since questionnaires sent through the mail or delivered from house to house are more likely to be answered by those who are interested than by those who are bored, and the results will not give a picture of the *whole* population which one is trying to survey. If the questionnaire is given in the classroom, everyone being required to fill it out, it must, nevertheless, be remembered that the class is itself a selected group. Even if a large city public school system is used, one must bear in mind the differences in racial composition in different parts of the city, the varying economic position of those who attend the different schools, and many other sources of sampling errors. It is possible to correct for such flaws, but the amount of labor is so great that for the more serious investigation of personality it is generally worth while to devise better methods rather than to put in the hundreds of hours necessary to make the questionnaire valid.

There still remain pressing problems on which the questionnaire is our chief source of information. When we are dealing with information which is socially important, yet is personal and private and therefore known only to the subject himself, we have to use this method. A number of recent questionnaires have shown that by keeping the subjects' identity from being known, either through withholding the name or not requiring the name at all, the fullness and accuracy of the results can be increased. The necessity of such precautions is brought out by one recent study of religious attitudes, in which 43 per cent of the students indicated that they would have answered differently if they had been required to give their names. The figure is not always as high as this, but if one asks personal questions and requires names, he usually has no way of knowing how much conscious or unconscious distortion there may be.

Both in ratings and in questionnaires, one seeks knowledge of

a general trait by asking about specific forms of behavior which exemplify it. Among traits studied by ratings are the following: aggressiveness, courage, extraversion-introversion, humor, modesty, originality, sociability, tact. Most modern questionnaires are so planned as to permit the checking of one answer out of two or more possible answers, so that the results for a large number of subjects can be classified. Typical of modern questionnaires are the "inventories" of traits relating to personal adjustment and mental health, with a series of questions about worries, ambitions, sex adjustments, attitudes toward brothers and sisters, etc. If such questions are carefully and not offensively worded, extraordinarily high consistency is obtained when answers relating to similar topics are compared; and the results are often helpful to students and those whose business it is to help them with their difficulties.

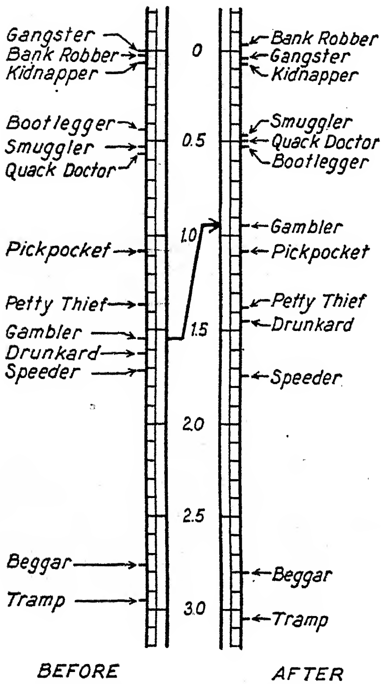


FIG. 114.—Propaganda effect of a motion picture. The two scales represent the seriousness of crimes as judged by 240 school children before and after seeing a particular film which dealt with gambling. Though other crimes remained at the same scale position, gambling was judged as a more serious crime after seeing the film. Construction of attitude scales of different kinds permits the study of many of the forces that mold public opinion. From L. L. Thurstone, *J. Soc. Psychol.*, 1931, vol. 2, p. 298. By courtesy of the editor and the author.

Attitudes and personal preferences are among the personality traits most intensively studied at present by such methods. So important are social attitudes that education is often defined primarily in terms of the building up of attitudes toward work and play, toward our own and other nations, toward public

policies and private standards. That the forces at work changing these attitudes can actually be measured has recently been shown, as two or three illustrations will help to make clear.

Attitude scales show the effect of propaganda.—Gross effects of suggestion when imposed by many persons or by one

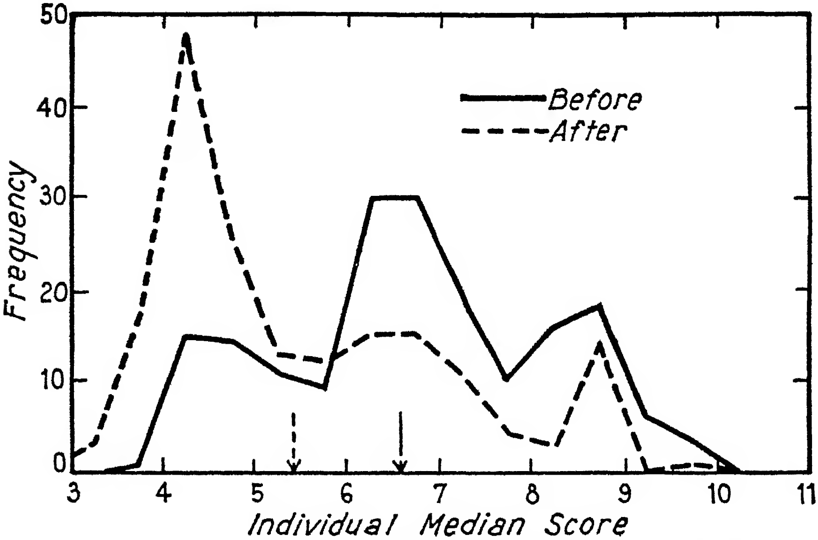


FIG. 115—The shift in attitude caused by propaganda. The curves represent attitudes toward the Chinese before and after seeing a motion picture film dealing with Chinese individuals. The whole group seems to have shifted toward the lower end of the scale used to measure the attitudes, on this test, lower score means a more friendly attitude. The arrows show the group averages. Such a study suggests the many subtle ways in which the general outlook of an individual may be influenced by apparently minor things in the environment. From L. L. Thurstone, *J. Soc. Psychol.*, 1931, vol. 2, p. 231. By courtesy of the editor and the author.

person using much repetition, are often called by the general term "propaganda." We all know that propaganda has powerful effect; but it is only recently that light from experimental sources has been thrown on the magnitude of consequent shifts of attitude and opinion. Figs. 114 and 115 show shifts in attitude as a result of seeing certain motion pictures. Such effects appear to be rather enduring, as shown by retests many months later.

Such emotional forces are constantly at work shaping children's

—and adults'—attitudes on almost every conceivable social issue. In fact, direct suggestion is usually effective on college students even when they are prepared for it. Students are profoundly affected in their expressed attitudes and feelings (about music, ethics, linguistic usage, social issues) when told the "majority opinion" on each debatable case.

For more complicated issues logical and emotional appeals are usually combined. A recent study made use of propaganda relating to the Manchurian problem About 800 students at universities in California, Ohio, North Carolina, and New York indicated their attitudes toward the claims of Chinese and Japanese in relation to the Japanese policy in Manchuria. Many of these groups, serving as controls, took the same attitude test two weeks later. Other groups were subjected just before the second attitude test to a vigorous presentation of one point of view by their instructor The points of view presented to these various groups were: (1) an intense declaration in favor of the Japanese policy written by a Japanese publicist; (2) an equally vigorous declaration favoring the Chinese attitude, of equal length and of the same general character; (3) impartial material prepared by the Foreign Policy Association. Large shifts in opinion resulted among the members of the experimental groups as compared with the very slight shift shown in the control groups In every group hearing pro-Chinese or pro-Japanese material, shifts were in the expected direction, despite the fact that the propaganda was easily recognized as such.

Since the personalities and lecture styles of instructors doubtless differed to some extent in this experiment, the results might in some degree be due to the relative skill of presentation in different classes. To control this factor, the procedure in the second presentation was reversed, with many new groups of students at the same universities, an instructor who had presented violent nationalistic material presenting impartial material, and vice versa. The same effect appeared. But the groups who heard *impartial* material showed a decrease in the number of intense pro-Japanese and pro-Chinese responses.

An even more important problem upon which little light has as yet been thrown is the relative permanence of such changes A recent study indicates that at least six months after the termination of a prolonged experimental study of race relations by means of direct social contacts, a group of white students held a profoundly different attitude from the one they had entertained before the experiment; and some of them, on returning to the South, found themselves at variance with the attitudes expressed by their friends.

On the basis of experimental and questionnaire data on religious, ethical, political, economic, racial, and international issues, it seems quite safe to say that most attitudes are determined in large measure in the period before adolescence, and for the most part by irrational methods.

There are also many *behavior tests* for the study of adult personality.—Among tests of personality as shown by *overt behavior* in laboratory situations, there is a recent test of "persistence," in which the subject shows how long he can stand a number of painful stimuli applied to the hands A test of "aggressiveness" measures the ability to gaze fixedly at an experimenter while one is doing difficult mental work. A test of "helpfulness" involves having one subject administer a difficult test to another subject, the first subject not knowing that his own considerateness for the second one is what the experimenter is really measuring. In all such tests for adults the standardization of methods is difficult In these tests, and in ratings and questionnaires, we must compute *test reliabilities*, or the degree to which the test items point consistently in the same direction The reliabilities will increase with the number of items; as the number grows large the chance errors will cancel out. It so happens that despite the apparent advantage of objective test methods, we have not, in work with *adults*, secured many tests which give consistent and clear-cut results, although the results obtained with carefully prepared questionnaires and inventories of personal traits to be checked are satisfactory as far as they go. Even social attitudes,

intangible though they may seem, can be rather accurately measured An objective test like ability to stand pain (mentioned above) might seem to give better promise than a paper-and-pencil test on race attitudes; but as the situation stands now, results are better on the latter There *is* some relation between the persistence tests and the behavior of students, and there *is*, despite cynical comments, a close relation between students' statements on paper-and-pencil tests of attitudes and their campus behavior (for example, in relation to fraternities, R O.T C., etc.); but what the margin of error in using such paper-and-pencil methods may be, we still know only imperfectly.

Personality traits which we measure are habitual ways of responding in social situations.—The *names* used to describe traits do not necessarily define anything which is psychologically *unitary* or *ultimate.* The determination of each person's amount of any given trait depends upon *a large number of distinct factors.* For this same reason, one can name practically any characteristic he likes—such as conscientiousness, trustworthiness, ambition, shyness, sense of humor—and by collecting verbal terms which are interwoven in practical use with one another measure the sum total of the things that enter into the trait Thus, if I report that I am afraid of my shadow, like to go in swimming, treat dogs kindly, and abominate advertising slogans, and if enough combinations of verbal expressions are found which stand for these four declarations, and if these verbal expressions are now combined to give the trait of fol-de-rol or abracadabra, we may show by statistical manipulation that this trait has been measured There is a great deal of difference between the *usefulness* of terms and their significance as valid clues in scientific analysis. Intelligence is a useful word, but, as we saw, it does not help us find out how human capacities are constituted Extraversion, aggressiveness, honesty are useful terms, but they do not tell the *functional units out of which behavior is made*, or even that it is in any real sense made up of *units.* Probably the popular names for traits do not correspond in any way to the true elements from which personality is made any more than the make-up of the

physical world corresponds to the famous four elements: fire, earth, air, and water. We *can* measure traits as they exist in people about us and use the measurements in many ways, but we have not found out how traits are made up or the appropriate units of analysis to employ in getting a scheme of the fundamental structure of personality.

Like other habits, traits depend ultimately on drives.—Our approach in Chapters IV-VI assumed the existence of many kinds of general trends Some of these are simple chemical or mechanical drives like hunger, thirst, and sex impulses Others are rather more complicated trends depending upon the dynamics of the nervous system—an example is the exploratory drive (page 64). Basically, then, the raw material of which human nature is made should be *qualitatively* about the same from one person to another Even age, sex, and race differences would appear to be matters of degree rather than of kind. All these basic trends can be modified by conditioning, by the formation of higher units, by inhibition, and by all those forms of habit formation considered in Chapters XIII-XV. This account has attempted to show the organism as a plastic and modifiable thing, showing all sorts of combinations of tendencies which are dependent upon the way in which the environment and the organism have interacted A personality trait might then consist either of a simple drive, a group of drives, or of one or more drives *in relation to particular situations.* We might say that a person is timid, meaning that he is specially prone to fear or has a *low general threshold for fear*; that is, we might define his characteristics solely in terms of *responses* without regard to stimuli. Or we might say that he is a "moral coward," meaning that *in a certain range of social situations* he is afraid to take a stand, although we do not mean to say that he is also afraid of death, disease, or the devil.

The two definitions might be contrasted by saying that in the first a trait is the amount of response of the individual in the direction Y; whereas the second would mean the amount of reaction of the type Y when confronted with the situation X. For

the purposes of this comparison it makes no difference whether we have found ultimate behavior units or not. As long as we can get consistent results by measuring *response Y*, or by measuring *response Y in situation X*, we are justified in speaking of the measurement of personality traits Almost any response tendency Y, whether innate or the result of the modification of an innate tendency, appears to some extent in everybody and to a large extent in some people. If the psychiatrist speaks of "inferiority feelings," the psychologist has no great difficulty in showing that everyone shows *some* of the behavior which this term describes; people vary from a small to a large amount of such behavior. Measurements of this sort practically always define situation X and response Y. For example, the question, "Do you have inferiority feelings?" would not mean much, it would be better to ask a large number of *specific* questions, such as, "Do you feel that you are not a good mixer?" In order to study inferiority feelings in general we should have to ask a great many questions, and, even so, we should never be sure that we had studied a trait in the abstract, and apart from certain kinds of situations In general, all such work, recognizing the fact that single elements of this sort do not necessarily have far-reaching implications for the whole structure of personality, tends to define a *wide range* of situations. For instance, in a recent inventory used at the University of Chicago, a great variety of questions relate to kinds of social situations in which inferiority feelings arise It is easier and more practical to measure the magnitude of the inferiority reaction by telling in how *many cases* it arises than by telling how *strong* it is in just one situation.

Personality types are patterns in which personal characteristics are organized.—*Type* is a word used in personality study in at least four senses, but it is doubtful whether more than one of these has any justification. The first and perhaps the commonest use is to denote the demarcation of extremes on a distribution curve For example, Fig 116 indicates the way in which individuals differ on such a trait as "aggressiveness", the amount

of the **trait** is measured along the base line and the number of cases at each point is indicated by the *height* of the curve. Here there are no sharply defined types, but all gradations of the trait

Second, in "bimodal" distributions (those with two peaks or "modes"—compare Fig. 117), the term type may mean tendency to belong to one or the other of the two main groups. This may be a convenient way of saying that the curve is bimodal, but that is about all there is in favor of this use of the term. The individual marked A scarcely differs from B; therefore, this technique of determining types has merely set up two main types in place of the exact measurements shown in Fig. 117.

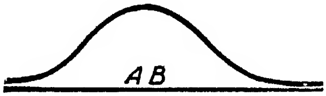


FIG 116

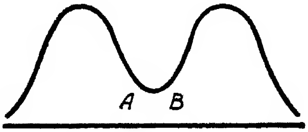


FIG. 117

FIG 116—The absence of "types" in a normal curve If we divide the group into halves on the basis of tallness (the shortest individuals at the left and the tallest individuals at the right), individual *A*, the tallest of the short half, is almost as tall as individual *B*, the shortest of the tall half

FIG 117—In a "bimodal" curve of this sort, there seem to be "types," but even here *A* and *B* are much alike though grouped under different "types."

Third, as in Fig. 118, the term type may be used to describe one's place in a distribution which is really broken in the middle, one curve is used to represent two contrasted groups of individuals who could in no way be confused. Compare strength of grip in six-year-olds with that among members of a major league ball team; the record would look like the following:

FIG. 118.—When the modes of a bimodal curve are drawn apart a point may be reached in which it is simpler to look at the matter in terms of *two distinct distributions*.

Here, since there is a genuine gap or break between the two groups, the term type may have some meaning. At any rate, to

say that the individual belongs in one type has more meaning than it has had in the preceding two cases.

Fourth, the term type may be used in a sense very similar to that in which we use it when we speak of printer's type; each letter has a particular arrangement or pattern If we have measurements of a number of personal characteristics and find that they are interrelated not in a haphazard manner but in an orderly and fixed pattern, we can rightly speak of genuine types. If, for example, in the inhabitants of eastern Asia, the height of the cheek bones, the width of the nose, the slant of the eyes, the ratio of weight to height, and a half dozen other physical traits are so interlinked that wherever we find some we find the rest, there is a meaning in speaking of racial types. But we must be careful in this use of the term, for the type may change or even disappear as the result of climatic factors or racial intermixture. In other words, we must study the matter biologically and ascertain those patterns which "stay put" no matter what hereditary or environmental forces may be at work. Some such cases have been found in biology Wherever one of these traits appears, the other ones are always present, simply because they are all traits in a unitary biological system. There seems a reasonable likelihood that there is a considerable number of patterns or linkages of human characteristics into types The endocrine system, for example, is a true *mode of integration or organization*, and not simply a case of "pluses" and "minuses" in endowment with respect to the activity of various glands.

It is on the basis of this idea of a biological basis for personality types, like the biological types found in animal experimentation, that the theory of *eidetic types* has grown up at Marburg in Germany. As a quantitative approach to the study of personality, these investigations are of immense interest and importance; they aim to give the psychology of human personality a rational foundation which will permit the description of systems of necessary connections between traits, such as have been studied in biology. These eidetic types must *not* be understood to be something already clearly established in fact. They are described to show *working hypotheses as to the organization of personality.*

Eidetic imagery is a characteristic of eidetic types of personality. The reader will recall the account (page 267 ff) of after-effects of visual stimulation. After the ordinary negative after-image has disappeared, an *eidetic image* may remain for minutes or even hours. Experimental work has shown that the kind of eidetic image which corresponds closely to the ordinary negative after-image appears frequently, if not always, in individuals who have several other characteristics in common One of these characteristics is irritability of the sensory and motor nerves and a tendency to high tonus of the skeletal muscles. The tense muscles and the pinched face are due to chemical disturbances, similar to those appearing in the early stages of strychnine poisoning and lock-jaw. Another characteristic of those endowed with this kind of imagery is the tendency to be fidgety, incessantly active, unable to relax; the motor disposition colors and helps to define the emotional trend The subject is often disturbed about the imagery itself. He does not want the images; they come in spite of him, and they refuse to leave when he tries to banish them They crop up like a tune which has run so long in the mind that one is unable to squelch it. In all this we have the "T-type," so called from the general resemblance to the excessive muscle tonus known as *tetany*. The type is defined in terms of the true *interlinking* of the physical and mental characteristics. Defect of the parathyroid gland (cf. page 61) plays an important part in bringing on this condition. It is the belief of Jaensch and the Marburg school of experimenters that some slight trace of this tendency is recognizable in a large proportion of normal children and that it usually weakens or disappears as the child grows up.

Another kind of "eidetic type" has imagery which is more fluid, less rigid, more like a memory image, less like an after-image Though rich, colorful, and vivid, this kind can be gotten rid of at will, and it can be recalled at will. It plays the part assigned to it by the subject in his thoughts and daydreams It is an intimate part of his psychic life; it is interwoven with his emotional needs, on the one hand, and. on the other, with the world of perception from which it was first derived. One might say that

whereas the T-type of person regards the eidetic image as an *intruder*, the type now described regards it as a *friend.* This latter condition is found in individuals with a rich and impulsive emotional life and a contemplative or reflective trend of mind. Physically there are many signs which cause it to be recognized as a mild form of what in more exaggerated form is known as Basedow's disease (or Graves' disease), a condition of excess thyroid secretion. This, the "B-type," is another *endocrine* type. Perhaps over-activity of the thyroid is the sole cause of all the other manifestations (imagery, muscular changes, etc); but in view of what is known about the interacting of all the endocrines, it seems more likely that we are dealing here with a general trend, balance or *mode of organization of the entire endocrine system.*

If one has grasped the logic behind these types described by Jaensch, and seen the reasons why pure types of *necessary linkages* of traits come first in his survey, one will expect next to learn that there are impure or mixed types. For example, incomplete T-types are found in many children in whom negative after-images are not of the usual complementary color but show a systematic distortion from the expected color. The child is subjected to a variety of optical experiments to make sure that the effect of this distortion is consistent and subject to known optical laws which are beyond the comprehension of the child, so as to eliminate the possibility that the child, by "suggestion" or for fun, is aiming at a particular kind of result. We cannot follow the Marburg school into these intricate paths. But it is of interest that even the incomplete types are studied for the light they throw on basic biological *organization* of personality traits.

We have shown the Marburg personality types merely as illustrations. There are several other ways of describing types and subtypes. It is frequently admitted by many of those who use the concept of personality types that experimental work in substantiation of these concepts is very incomplete. The concept is, nevertheless, so important that it is worth while to emphasize it as one possible clue to individuality, the distinctive *way* in which the personality is built On general psychological grounds, it is ex-

tremely likely that there are true personality types which are not merely various parts of a normal frequency curve. The presence or absence of a given chromosome and the consequent presence or absence of some trait, depending wholly or partly on that chromosome, suggests differences between persons which are not simply differences of degree. Of course, if a trait arises from a number of independent factors, as intelligence seems to do, and if we have appropriate measuring scales to measure the degree of each trait possessed by each person, we are able to think in strictly quantitative terms. It would be very desirable to measure *all* individual differences in this way if these differences are due entirely to many separate factors. Some personality traits, however, are probably due to such a complicated pattern of interacting forces that they seem qualitatively unique; at least for the present, we cannot intelligently fit them into a distribution curve. There is apparently an *organization* of hereditary characteristics which for all practical purposes is unique.

SUMMARY

When personality differences are a question of degree, not of kind, they can be measured. Personality may be roughly measured by the ratings of those who have observed a person closely When the desired information is personal and private, the questionnaire is used, care being taken to overcome both sampling errors and the desire to withhold information Questionnaires, when properly administered, are suitable for the study of social attitudes. The results from rating scales and questionnaires are best understood as measurements of *habitual* behavior, which in turn goes back ultimately to ways in which drives are expressed in social situations. Measurement of a trait, however, is usually a measurement not of a single habit expressing a single drive, but of the way in which habits are organized within the whole personality

The study of personality types at times goes beyond our present quantitative methods, because the way in which the person's

characteristics are organized is sometimes not just a question of degree but involves a complex pattern.

REFERENCES

Allport, G W , and Vernon, P. E., *Studies in Expressive Movement,* 1933.

Jaensch, E. R., *Eidetic Imagery and Typological Methods of Investigation,* 1930.

Sharpey-Schafer, E A , *The Endocrine Organs* (2 vols), 1926.

Symonds, P M *Diagnosing Personality and Conduct,* 1931.

PROBLEMS

1. How might short-sample observation methods be used with adults, e.g , in theaters, street mobs, juries, political bodies?
2. In studying political attitudes, what would be the differences between results from a questionnaire study by paper-and-pencil methods and results from a house-to-house canvass? What could be accomplished by each method? What sources of error are present in each? How could the two methods be used so as to permit detection and elimination of the errors resulting from each one?
3 If raters disagree grossly, how can we determine who the best rater is?
4. If ratings agree well, what right have we to assume that they are accurate, rather than that the raters all have the same bias?
5 Many attempts have been made to measure personality through blood pressure, alkalinity of saliva, etc , on the assumption that endocrine and other chemical activities in the body are unquestionably related to personality The results, though often of interest, have failed to yield good "personality measurements" Why do you think this is so?

CHAPTER XXIII

THE THEORY OF PERSONALITY

HAVING seen how personality "grows" and how it may be "measured," we shall have to ask what it *is*—a question more difficult than any we have asked heretofore in this book Since it is quite impossible to treat all the theories, attention will be given to a few sharply contrasting ones, namely, those of Watson, Janet, Freud, Jung, and Adler.

WATSON

Behaviorism regards the conditioned response as the basis of personality.—From the viewpoint of J. B Watson, personality is developed, or cultivated, or "built," in terms of the establishment of *conditioned emotional responses.* A man who, as a child, was frightened by an over-strict father may be ill at ease and timid in the face of any business superior who is like his father. The boy who has been over-dependent upon his mother or over-affectionate toward her may, years later, fall violently in love with a woman who has no special attraction for him except her resemblance to the mother; and this may occur whether the individual is aware of the resemblance or not A child who has been humiliated by the scorn of her music teacher is found, years later, to feel bitterly resentful toward all professional musicians and to think that compulsory music lessons for small children are barbarous.

All these character traits up to this point are rather specific. Yet much more general claims may be made For example, in a child who shows fear in all new social situations, this condition is said to be due to an early conditioning in which he was made to

"speak a piece" when he was unprepared. A child with a hostile attitude toward everyone who interferes with what he likes is said to show the result of unwise restraint by his nurse when he first began to reach for things. As we have seen, conditioned responses may be brought out by stimuli which are only remotely similar to those which first aroused them. The theoretical character of this view is fully admitted. We not only know little about the limits of conditioning, and the permanent effects of the conditioning experiences in childhood; we know that many conditioned responses die out quickly unless reinforced and that the complexities of experience usually result in the dropping of irrelevant and useless responses. The timid response, for example, ought to disappear when the child finds that people are really not so brutal. A generalized character trait could be built up by true conditioning only if there were incessant repetition of the original stimulus, the latter being presented with a wider and wider range of conditioning stimuli. The behaviorists believe this occurs.

No one has ever studied a child in the process of growing up to see how far a personality can actually be shaped in this way. This is another reason for doubting whether the conditioned reflex principle could explain the whole formation of personality. Most students of childhood no longer believe that the behavior at birth suggests the range of hereditary capacities; they think that innate differences, not only in obvious but in subtle traits, continue to appear through maturation month by month and year by year during the entire growth period, perhaps even throughout life. Innate temperamental factors may well play an important part in determining the extent to which later conditioning experiences may be able to do their work What seems to be an identical conditioning experience may have a slight effect on one child, a profound or even permanent effect on another. The evidence regarding the glands and unstriped muscles and their importance in relation to some personality traits makes it reasonable to believe that some kinds of emotional conditionings are easy to bring out and profound in their effect in some persons, hard to elicit and of small consequence in others.

How much can be done to personality by the whole social organization—the emphasis of society at large upon the desirability or undesirability of certain personality traits—is again a broad question. There are at work many forces which tend to make certain emotions unacceptable or unworthy in some societies and to make them the chief basis of personal worth in other societies The ideal of absolute self-control may give way to the ideal of the spontaneous expression of all sorts of emotions. People of the same racial stock may be cold or impulsive, depending on their training. National character may actually change fundamentally in a few centuries. Possibly all such social influences may be shown to operate by the specific conditioning of specific emotions; but in view of the complexity of the learning process we do not feel justified in this assumption.

The individual differences in emotional make-up and in the pattern of personality might be even more important than they are if the social standard to which we try to conform did not in many ways limit the importance of such individual differences by making us more or less alike in the social traits which our civilization emphasizes.

This brief statement refers only to the behavioristic *theory of personality*. Other aspects of behaviorism are mentioned on pages 518-520.

JANET

Janet believes normal personality to depend on "psychic tension," or capacity for synthesis.—The foregoing theory of personality is an example of an objective theory; personality is considered to be an observable behavior pattern. Many of our theories of personality, however, have been undertaken in a different spirit, concerning themselves with personality "from the inside," and meaning by personality study the attempt to explore the inner world of each person.

A fundamental difference between almost all psychiatry, on

the one hand, and almost all psychology, on the other hand, is the different emphasis on the self or ego. Psychiatry recognizes frequent distortions in the person's awareness of self; loss of social perspective, delusions of grandeur and persecution, the feeling that one is no longer the same person, even denial of one's identity are experiences rather commonly reported to the psychiatrist He finds that the sick mind is seldom sick with respect to some single function relating to contact with the external world It is the whole self that is sick. The ordinary relation of background and foreground which appears when one concentrates on a book, yet is all the time aware *who* is reading, is thrown out of balance. The external world may be forgotten and awareness of self become dominant, or vice versa; in other cases, the awareness of self undergoes qualitative transformation

With this interest in the self as a starting point, the French physician Janet, on the basis of experience with neurotic patients, worked out the following theory. The mind is essentially an aggregate of parts; each part may be considered a sensation, or image, or group of images (called an "idea"). For Janet, however, the parts are not glued together by "association." There is no natural tendency for one idea to stick to another On the contrary, ideas normally tend to be held together in the integrated total of the personality by virtue of a biological principle similar to that which keeps all the parts of the body functioning in an entire system. This unifying principle is "psychic tension" In the normal individual, psychic tension is sufficiently high to allow the various ideas to hold together In times of great stress, however, certain ideas may be more or less broken off from the rest. This is a failure in synthesis. Here an idea may seem not to belong in the integrated totality of the self; we have a "fixed idea"—for example, an obsession or an absurd worry which keeps coming back although its complete absurdity, and its irrelevance to the real and immediate issues of life, are fully seen. It is a common experience of the psychiatrist to find in a worrying patient that what he or she worries about has no real relation to the life which has to be lived In Dickens' *David Copperfield*, "Mr Dick" constantly worried

about the execution of Charles I which happened two centuries before. Janet would say that an idea is obsessive because it is so poorly interwoven with the rest of the mind that it cannot do its normal work; but he would not say that this obsessing idea is the *cause* of the trouble On the contrary, it is obviously the *result* of the trouble One cannot understand the worries of the neurotic by finding what ideas obsess him One must know the *cause* of the obsession, which is usually something quite different The point is that some ideas have got loose from the whole pattern; just why this occurred, and why these particular ideas were shaken loose rather than others, can be discovered only by what Janet calls psychological analysis—a careful life-history study of the patient (of course, not the same as "psychoanalysis").

In some cases the idea which becomes dislocated is not apprehended merely as something separate from the self, but takes on a strange quality or a power to terrify the patient. When psychic tension is sufficiently reduced, these alien ideas may seem grotesque and horrible or they may come swinging back toward us in the form which Janet has brilliantly described as "memories which are too real." In some special cases they may be ideas referring to movement, in which case a compulsive act like Lady Macbeth's forced and endlessly repeated hand-washing may appear Thus ideas which haunt us, "obsessions," are closely related to "compulsions," acts which we are impelled to repeat over and over. Where the idea has a capacity to arouse fear without other manifestations, we are dealing with "phobias"; and these three—phobias, obsessions and compulsions—make up the group of disorders to which Janet gives the name *psychasthenia.*

Frequently the ideas described above as "torn loose" from their normal connection with personality are *completely* broken off in such a way as to be forcibly thrown out of consciousness into that region known as the subconscious. The psychic tension has been so far reduced that like a rapidly whirling star the whole system has broken in pieces, of which only one, the big central one, can be regarded as strictly personal. An hysterical paralysis, for example, may occur when the ideas which ordinarily lead to bodily

movement are completely shut out from consciousness, or dissociated; in the same way insensitiveness of a part of the body, such as loss of feeling in the fingers or blindness in one eye, may represent a loss in the total range of functions represented by the ordinary self It should be noticed that Janet sticks to his more obvious findings here, and is content to regard hysteria as simply a more extreme form of psychasthenia, that is, an instance in which the lowering of psychic tension has gone so far that the supposedly "lost" functions are actually still recognizable as present in the personality.

For Janet and his followers the royal road to the study of all these phenomena has been the use of *hypnosis*, and we shall try to indicate what he means by this term.

Hypnosis is a method, *par excellence*. for producing dissociation (cf. page 351). The more profound forms of dissociation are produced in a quasi-sleeping state in which the subject still keeps his attention upon the hypnotist—hearing his voice though deaf to other sounds. The hypnotic technique usually includes monotony and eyestrain, as well as fixed attention. After a few minutes of quiet concentration upon the hypnotist, while in a relaxed bodily posture, the subject begins to pass into an "hypnotic trance."

Among the ordinary phenomena of hypnosis are the following:

1. Loss of a muscular function, shown either in paralysis or in rigid contraction of muscles; sometimes abolition of reflexes.
2. Loss of a sensory function, especially sight, hearing or touch.
3. Loss of memories, immediate or remote.
4. Loss of the capacity to decide or will a course of action.
5. Appearance of independent functional capacities which have been dissociated For example, automatic writing, crystal vision, etc. (Cf. page 352.)
6. Later reappearance in consciousness, or in behavior, of elements which have been dissociated from consciousness at an earlier time Let the subject, for example, be told that five minutes after awakening he is to go to the corner of the room and get a book. About five minutes after he wakes, he

begins to look restless, makes toward the corner of the room, picks up the book. If asked why he does so, he seems to be unaware of the fact that the command has been given.

Such instances as the last show clearly why Janet—and most other hypnotists—regards the hypnotic state as ideal for the production of dissociation. All the dissociation which occurs spontaneously in hysteria can be made to occur *experimentally* in hypnosis. There are also other theories of hypnosis, some of which differ sharply from that of Janet; yet almost all of them emphasize dissociation as a clue to the structural pattern of personality. Just as one understands a clock by taking it apart and putting it together, so one understands the structure of personality by experimentally separating and then reassembling the parts. Hysterical symptoms, being *expressions* of dissociation, can be dispelled when the hypnotist gets access to the semi-sleeping mind and helps to reassociate the parts which have become dissociated But dissociation, and hypnosis, offer useful techniques in the study of normal people; and the hypnotic study of normal people is now going on in several laboratories Dissociation is one of our best general clues in personality study.

FREUD

Freud's theory of personality emphasizes (a) sexual cravings, (b) fixation on the parents, (c) identification with the parents.—Janet and Freud began work on their theories at the same time—fifty years ago. It is in this context—the context of the psychiatrist striving to understand the dissociation of personality—that one must understand the psychoanalysis of Freud and his followers. Freud's theories began by being very simple, almost obvious. As more and more difficulties were encountered and a greater variety of problems presented themselves, his theory became more complicated—far too complicated to be described here, except in a few elementary aspects.

Freud believes that what we call personality is largely the result of social contacts and social pressures. A child from earliest infancy is shaped into the pattern of the family and of the social, religious, and national groups to which the parents belong. Part of the process of shaping the child consists in checking or inhibiting some tendencies, especially the cravings which, in a broad sense, Freud believes to be sexual. He thinks of the libido, or sexual energy, as a broad general principle in life, like Plato's idea of Eros, and not simply as the adult attraction between the sexes It is thus possible for him to believe that most impulses are, in this very broad sense, sexual.

The conflict of impulses results in *ego* and *super-ego*, which combine against blind forces in the *id*.—Before any inhibiting has been done, the infant follows the "pleasure principle." He knows nothing of good or bad or high or low. He has, in fact, no ideas and is not aware of himself or of conflict between his needs and the wishes of those about him In Freud's terminology, the "ego" has not been formed. The child's mind is simply a series of pleasure-seeking activities; to this set of activities we may give the impersonal name "it." In the course of time, however, the child's blind strivings come into conflict with obstacles which cause frustration or pain; the "ego" begins to emerge from the "it" as the child becomes aware of his own existence. Just as *ego* is Latin for "I," *id* is Latin for "it," so that the followers of Freud divide the little child's mind into "ego" and "id."

The child learns through parental discipline, and other hard experiences, that he cannot use the world as he will This is the emergence of the "reality principle" Moreover, the words used in training the child include many which refer to him, e g , his own name and the various pronouns which are applied to him. Words referring to him as an individual become associated with one another and tend to be regarded as something marking him off as a *social being*, in contrast to the blind instinctive strivings against which his family offer so much resistance. In this way the original id (it) becomes split into two parts, one remaining on a primitive instinctive basis, the other becoming the socially ap-

proved and recognized self or ego. One justification offered for this concept of duality in personality is the fact that in the process of psychoanalysis one discovers that the simple opposition between conscious and unconscious aspects of the self will not suffice to explain symptoms. For example, consider the case in which a patient struggles to recall a painful episode which may lie at the root of his trouble, but, in spite of all his efforts, cannot bring it back. Obviously the id, governed by the pleasure principle, is not resisting this chance for free expression Freud concludes that it is actually the ego which is unwilling to recall the episode. A man might, for example, wish to know why he disliked a certain shape of chin, and with all the powers of his conscious ego try to recall why this prejudice arose. The trouble, says Freud, is that the part of the ego which fights against recall is itself unconscious. The ego is partly conscious and partly unconscious. This means that in the functional organization of personality it is not sufficient to separate conscious and unconscious. One must also take account of the sets of impulses within the personality, governed by a real opposition in purpose and not merely by the attributes of consciousness or unconsciousness.

The primitive cravings of a little child become fixated upon the parents. The mother is at first the object of affection; this is then extended to the father also. The relative emphasis given to the two forms of fixation differs for boys and girls at different ages. In our own society, there is a tendency for the little boy to *identify* himself with his father, to play that he *is* his father, to want to be like his father. This tendency competes with the vague desire to belong to and to possess the mother, so that jealousy and a resulting conflict are set up In this situation the child cannot help loving and hating the father at the same time; this Freud calls the *Œdipus complex.* The emotional attachments to the parents change from year to year, being reinforced by some circumstances and inhibited by others. The little girl remains fixated on the mother for a while. Transference of affection to the father later involves the same kind of conflict, since she identifies herself with her mother. For both sexes both parents are objects of intense

affection as well as of resistance and antagonism As the boy or girl grows, the painfulness of this twofold attitude toward the parents becomes unbearable and one of the attitudes has to be repressed; under ordinary conditions, it is the attitude of hate. The child loves its parents consciously, but a permanent hostility remains which only a deep analysis of the personality can make plain. The origin of many of the most important manifestations of personality in later life can be traced to these emotional conflicts of childhood.

The ego theory did not completely satisfy Freud, for it seemed to offer no true explanation of *conscience* and the urge to conform to moral and other social standards. In the earlier years of psychoanalysis it would have been sufficient to explain conscience in terms of the ego. Later studies showed that the analysis of the ego did not lay bare the origin of conscience—in particular, the feelings of *guilt.* A person may be desperately sick, mentally obsessed by a sense of his guilt or sinfulness, but the trouble does not seem to have its origin in the ego. Analysis of such cases led Freud to conclude that the original trouble was the tendency, already mentioned, for the very small child to *identify himself with one or both of the parents*—the little boy's tendency to put himself in the father's place, and to assume toward his own ego the attitude which his father would assume. Part of the little child's personality looks upon his own ego with disapproval, regards it as naughty and wishes to punish it; this usually results in the repression of a group of tendencies which become hard to reach. This part of the personality which undergoes parent-identification and looks upon the ego with a stern and critical eye, is the "super-ego." In later life it may harass the ego by burdening it with a sense of terrible sinfulness and unworthiness. The super-ego is ultimately derived from the same unconscious forces which we have already described as the id; but in cases where the super-ego is hostile to the ego the latter has its hands full in trying to master both the instinctive cravings and the accusations of conscience

Childish habits persist in adult life.—Often conditioned emotional responses somehow get fixed in the structure of person-

ality and fail altogether to be eliminated by "extinction" or "reconditioning" (page 246). They seem to cling despite all the subject or his physician can do. Several reasons for the difficulty have to be considered. In the first place, any strong emotional reaction tends to be woven into the whole tissue of personality; it is no longer a detached symptom. If a habit is constantly exercised, it will probably sooner or later come to serve some purpose. The fear of dogs may be silly enough; but if one time in a thousand it actually protects us against being bitten, we are apt to remember this one time and perhaps even congratulate ourselves upon having been wise and reasonable all the time Nothing is commoner than for people to protect their prejudices by pointing to single instances in which the prejudices have been useful (For every such case there may be hundreds in which the prejudice caused conflict and pain to everyone concerned. However, it takes real effort to get rid of a mental habit, and if we have a convenient excuse for not getting rid of it we seldom make the effort.)

It is therefore characteristic of habits to interweave themselves with other habits in a stable structure There is, however, a more important reason for failure to eliminate conditioned emotional responses. They are not accessible to reconditioning because they have been "repressed"—forced out of consciousness. They are repugnant to what we like to think about ourselves, but they continue to act as *motives*. Consider, for example, the universal and obvious appeal of crime and scandal news Few people can really get along without a certain amount of reading or talking about such things; almost every civilized person likes to read detective stories. Every now and then a newspaper tries the experiment of printing no crime news for a couple of weeks, but this does not pay.

If we hate crime with a pure and unmixed hatred, why do we have to read about it? Do we not have a sneaking desire to be bold bad men? We have taken as an illustration our tendency to enjoy crime stories, but we might have taken hundreds of others, all of them instances of how some parts of our nature get a pleasant

exercise although in direct conflict with the ethical and socially acceptable self.

Rivers reports an instance of a more violent kind of conflict between emotions. During the World War, a medical officer in the British army had a mortal terror of dugouts. This officer had been wandering up and down the trenches where he was subject to every kind of danger, but he was terrified at the sight of a dugout which would have offered him protection The man was sent home because of the greater and greater anxiety and tension he had shown at the front. Though the patient made a prolonged and earnest effort to recall the origin of his trouble, he was unsuccessful. All his life he had been afraid of small rooms and of underground places such as the subway. He recalled sleeping, at the age of six, in a box bed. But this did not seem sufficient explanation Why should he have been afraid of a box bed, when so many children of his age slept well enough in these or even more confining places? He was urged to keep a careful record of his dreams, devoting the first few minutes after awakening each day to study of the dreams he had just had. Shortly after starting to do this, he recalled the following scene: As a little boy he was walking through a dark passageway and was suddenly confronted by a dog which terrified him This was a true memory of an incident which had happened when he was a very small lad. The passageway had been in a junk dealer's house near his home, and the dog belonged to the junk dealer Apparently the fear of dark passageways had been fixed since the age of four years A conditioned fear, one would say Yes, but this is no real explanation. Why have not dozens of other experiences in dark rooms, resulting in *no* damage or danger, "reconditioned" the patient? Why has not an endless succession of harmless experiences swamped and crowded out the original fear?

The answer is related to the fact of *repression*. The fear of the dog—in fact, the fear of the whole situation in which the dog appeared—was so horrible that the little boy could not stand it. He had forced the whole terrifying experience out of his mind.

What has never entered consciousness, plus what has been repressed, makes up the unconscious.—Freud thinks that only a small part of the mind is conscious. As "the unconscious" is by definition outside of consciousness, we cannot know what an unconscious state of mind would be like. There are many psychologists who insist that an unconscious state of mind is a contradiction in terms. From the point of view of logic this will, of course, be true, if the term "mind" refers only to conscious things. Our chief interest, however, is not in terminology, but in the study of instances in which important forces in personality may be discovered to be at work, although they are not open to direct observation. In the above case, for example, the man feared dugouts just as he had feared all dark enclosures, but he had no idea in the world why he did so Something deep in his personality, namely, a dread dating from the time he was four years old, expressed itself in a dream, and when close attention was paid to the origin of this a clear interpretation of his trouble was obtained. As soon as the episode of the dog was clearly remembered, the fear of dark enclosures completely disappeared. In other words, the experience was *reconditioned* when it was *consciously recalled,* though for more than thirty years it had escaped reconditioning when it existed in the form of an unconscious mental conflict.

Freud believes that mental health depends on the education of the basic emotional drives so that they may find an acceptable outlet.—For a complete, lasting cure, a more complicated process is usually required, involving the recall of many early conflicts. When the patient begins to recall and relive the emotional conflicts of his childhood, he assumes toward the psychoanalyst an attitude such as he had, as a child, toward his father; this attitude, known as "transference," is essential to cure. When the unconscious sources of trouble are found, reeducation of the emotional life follows.

One may think as he likes about Freud's theory of the unconscious, but he can hardly dispense with the light which such conflict throws upon the structure of personality. Though this account is far too brief and schematic to give a picture of Freud's

psychology, the reference to *repression* is sufficient to show how far Freud's theory is from behaviorism.

JUNG

Jung's use of the association test was suggested by psychoanalytic theory.—Freud's work aroused enthusiasm among psychiatrists in the German-speaking countries, many of whom began similar investigations. It is not strictly correct to call all these men "followers" of Freud, and it is definitely wrong to call them all psychoanalysts. Jung, in Switzerland, began to use rather similar conceptions; and he succeeded in adding to Freud's theory, one of his most successful studies being the systematic description of a mental disorder, "dementia præcox," in terms of the combined effects of mental and physical disease processes, in which the mental processes were to be understood psychoanalytically. The reader will recall Jung's use of the free association test, which we have already described (page 106). Jung prepared a list of one hundred standard words which were found to have value in bringing out emotional responses which might throw light on the patient's trouble. He found, for example, that a number of nouns and adjectives which are reacted to in a matter-of-fact way by most of us, such as the words *head, river, sky,* and *green,* would be reacted to by some subjects with emotional responses such as *horrible, disgusting, hopeless,* and *damnation.* Words like these might throw light on the kind of emotional trouble from which the person was suffering chronically, and might show to the patient himself many things in his own mental make-up which he had previously failed to recognize. Jung found that the patient would often reveal his difficulty to himself so clearly as to need no further proof from the analyst regarding the nature of the repressed thoughts which were disturbing him. The test might be used in the midst of a psychoanalysis or as a convenient starting point for an analysis. The revealing of these repressed complexes or groups of ideas by means of the association test was an important contribution Jung even imported into his studies the use of

the galvanic skin reflex, by which electrical changes in the skin were shown to accompany peculiar sudden bursts of emotion.

Jung does not regard the basic instinct or "libido" as sexual, but as a universal psychic energy.—Till 1912 he contributed to the healthy development of Freud's psychoanalysis through the introduction of experimental methods and through the extension of the contact between psychoanalysis and laboratory psychology. Yet Jung protested that Freud was confused in using the term "sexuality" in two senses—the one narrow and explicit, the other general and philosophical, corresponding to Plato's idea of Eros. Jung rejected the notion that sexuality in the narrow sense plays a central part in emotional maladjustment, and thought rather of the "libido" as a universal psychic energy or will to life, expressing itself now in one, now in another, instinctive channel. In this way, though continuing to use much that he had learned from Freud, he found it possible in many cases to explain nervous disorders without reference to sexuality.

Another difference of some magnitude between Freud and Jung lies in the emphasis given by Jung to the idea of emotional attitudes inherited from our ancestors. Jung has expounded this to an extreme degree, explaining the symbolism of dreams, of literature, and of mythology largely in terms of ancestral experience. This, of course, is contrary to biological opinion regarding the nature of heredity, since biologists believe that only *definite structures*, not attitudes, are inherited; and mental states, as far as we know, are the results of experience within the individual's lifetime as he uses his body in response to the world. Jung, however, was not disturbed by such opinions. In addition, he held that the unconscious is primitive and irrational; it thinks symbolically not because of repression, but because this is the nature of free uncritical thinking.

In order to guide the person's growth, Jung believes it necessary to discover whether the person is extraverted or introverted.—Another addition made by Jung to analytic theory is the concept of *personality types* (cf. the concept of type described on page 488). Very early he had come across two radically

different ways of confronting life situations The "extravert," as we have seen, directs his emotional energy outward primarily toward the objects of the physical world, including, of course, persons in the social environment. The extravert as conceived by Jung is the practical, objectively minded person, the hand-shaker, the organizer, the good sport, the busybody, and so on; the terminology depends, of course, upon one's degree of enthusiasm for this kind of personality. The "introvert" is a person whose emotional energy is directed inward, that is, toward the realm of fantasy and imagination. Yet either of these types may express his tendency through thought, feeling, sensation, or intuition; we have, therefore, the thinking extravert, the thinking introvert, the feeling extravert, the feeling introvert, etc. And whatever tendencies are apparent in consciousness are balanced by opposing tendencies in the unconscious. It is impossible to carry out effective psychiatric work until one has discovered to what personality type the patient belongs.

ADLER

In 1902 a group of young medical men began to meet weekly with Freud in a private seminar for the discussion of psychoanalysis. The group expanded rather rapidly and began to include many who were not strictly followers of Freud Among these was Alfred Adler, who was especially interested in the fact of *compensation.* Many of the symptoms of nervous persons had been attributed by Freud to an attempt to correct for, or compensate for, real or imagined weaknesses, particularly the sense of guilt.

Adler believes that the first reaction to life is a sense of weakness.—Adler noted that the fact of compensation for weakness is one of general biological importance The animal with an injured eye may become very sharp-sighted in the other eye Injuries to muscles frequently result in a compensatory growth of some other muscle which serves the same function. This is not a matter of conscious purpose. Even the loss of a kidney results in

the compensatory growth of the other. Such compensation would naturally arise wherever one organ was weak, or injured through early accident or disease. It seemed to Adler that a large part of the behavior of the mentally sick person could be understood in terms of his attempt to balance or compensate for a weakness, an attempt which was seldom clearly conscious. Not only did the physiological responses compensate for physiological defects; the mind was itself an instrument of compensation, a tool to build for the individual an adaptation through which he might achieve that which his defect would otherwise place beyond his reach. This doctrine, propounded in 1907, Adler consistently amplified and enriched, paying less and less attention to organic defect and more and more attention to the sense of inadequacy and the psychic compensation through which the person achieves a sense of importance or dignity sufficient to balance his sense of weakness or frustration. In time, Adler had perfected a system of "individual psychology" in which but little attention was given to Freudian principles, but sense of weakness and the urge toward compensation were made central It became evident that individual psychology and psychoanalysis could no longer live under the same roof

Adler founded his own *Journal* for the publication of researches along the lines he had defined. The next few years brought a series of papers in which the fundamental *purposive character of symptoms* was explained. The patient, without knowing how or why, develops symptoms which glorify him or protect him or give a field of operations in which success is sure to be achieved Not only are many neurotic symptoms obvious devices for making the sick person the center of attention, but many of them have more remote and less obvious origins. They may repeat childish habits by which an easy conquest was achieved in the childish environment and in which an attempt is made to perpetuate conditions under which such conquests can be won. The Adlerian psychology regards all mental sickness as derived either directly or indirectly from humiliation and a sense of failure, and believes

that every patient aims at the removal of such humiliation and the acquisition of a sense of power or prestige.

In addition to these general points, a few specific ones should be noted. First, the distinction between conscious and unconscious is for Adler arbitrary as well as unimportant. We are conscious of those parts of our personalities of which we wish to be conscious. Those things about ourselves which we wish to know, we know. The whole technique of remembering and forgetting is like the technique of anything else; all techniques serve the superiority purpose. Second, no specific drive, such as the sexual, plays any important part, except as it serves as a way of expressing the more generalized drive of the will to power or prestige. ✓ The frequency of sexual maladjustment is admitted, but the reason is simply the frequency with which disorders of this sort can be used to compel pity and attention. Third, the earliest years of life are fundamental for determining the basic way in which the individual will achieve his compensation All little children are inferior. They are weak, ignorant, and clumsy They desperately want what they do want, but they are surrounded by adults and older children who mete out to them only such satisfactions as suit the whim of the stronger The initial inferiority is peculiarly acute when the child finds that his brothers or sisters enjoy the greater favor of the parents.

The way in which power is to be achieved by the child depends on the family situation.—On this account "only children" are often unable to adjust satisfactorily to the world. The oldest child, who has been the baby of the family only to be replaced by others, bears the permanent marks of the conflict and permanent patterns of compensation derived from the original childish effort to be somebody despite the process of "dethronement." The youngest child, who has been given a peculiarly easy situation as the permanent baby of the family, encounters in life a difficulty even greater than that confronting the only child. In addition to these general differences depending upon position in the family are specific differences depending upon the age of the parents, the social and economic status, and the difference between the various

children in age, their physical attractiveness, the appealingness of their personalities, and a hundred other considerations The family pattern has a permanent place in the structure of personality, for although the pattern may change (the home breaking up or the relative positions being altered through death or going away to school) the modes of compensation which have once been set up tend to persist throughout life

The "style of life" is the individual's own way toward power and prestige.—All later symptoms in an individual's life are reflections of the basic pattern established in childhood. It is, therefore, strictly correct to say that from the point of view of individual psychology, any personality trait is a reflection of the whole style of life. Personality is not the sum or even the integration of the separate traits It is a unitary mode of adjustment in relation to which each specific activity or interest must be seen.

THE COMMON GROUND UPON WHICH THE PSYCHIATRIC THEORIES REST

By glancing back at the psychiatric theories of Janet, Freud, Jung, and Adler, a few major aspects of personality common to *all* these theories may be recognized; and to avoid failing to see the forest for the trees, it may be worth while to offer in new wording a brief view of personality which may be regarded as a sort of "greatest common divisor" of them all

Janet, Freud, Jung, and Adler all emphasize (a) conflict, (b) unconscious motives, (c) the necessity for understanding personality as a whole.—If we rule out cases of constitutional defect, we find that nearly all the abnormalities of human motivation and of personality are instances of *conflict*. Disorders of personality are almost without exception instances not of defect of motive, but of *antagonism* or struggle between motives. Most modern psychotherapy consists in finding ways in which two or more discordant motives can be brought harmoniously into line with an object which will satisfy them all, or ways in which crav-

ings which have been squelched or repressed may be brought into rational relation with those which find normal expression. The problem is to determine how it happens in human beings that motives declare war upon one another.

Conflicts of motive are not limited to human beings. Everyday observation of the dog who wants to see what you have in your hand, yet is afraid to approach you, suggests laboratory experiments in which two motives have been simultaneously excited. In all animals below man, however, the law of dominance holds good (cf. page 245); the stronger motive simply wins and the weaker motive simply fails to find expression so that the signs of mental abnormality do not appear. The trouble with man is that he has a rich symbolic life which makes it possible to keep motives alive though their stimulus situations are absent. Most conflict in animal behavior could probably be avoided by avoiding situations in which antagonistic motives would be simultaneously aroused; but man carries about with him memories, whether pleasant or painful, and these struggle from time to time with the tendencies which are actually at work in the reaction to a present situation. It is not always true that these are pleasure-seeking motives. The recurrent terror is a phenomenon of the nursery as well as of the financial center. The very fact that intensely motivated conduct tends to leave permanent traces means that old symbols may always start new disorders. Sometimes conflict is between the conduct prompted by the symbol and the present stimulus situation, as when a recollection of something that went wrong while driving under similar circumstances on a wet street disorganizes the driver's present adjustment. Sometimes, however, it is worth while to emphasize conflict between two present drives which are opposed and approximately equal in intensity. That one drive cannot "kill off" the other in normal adults is due primarily to the fact that motives have become so complicated by their interconnection with all sorts of other motives that a simple one-to-one struggle between elementary trends seldom appears.

The momentary conflict between two ways of spending a small amount of money is normally no cause of maladjustment. After

the dime is spent on the ice cream, the normal individual is not disturbed by the symbolic form in which the tendency to spend it on some competing object comes back to him. This is, however, exactly what does trouble the maladjusted individual. Hours or days of regret and self-accusation may follow because the dime was not spent on one or another of a thousand other trivialities. Here we are, of course, tempted to suggest that there is something at work in the personality that is *not evident on the surface*—the choice between the two motives was not really as simple as it seemed. Each of the possible ways of spending the money may have been bound up with the individual's whole emotional adjustment; perhaps, too, the act of deciding has itself become symbolic of a basic conflict, because wrong, or at least painful, decisions lie in the past.

All theories recognize the necessity of seeing personality as a whole. Evidently in all the more complicated phenomena of maladjustment, struggle between motives takes the form of an intricate pattern in which various aspects of personality prove to be incompatible with others. A relatively complicated analysis of the whole personality is usually necessary. By one device or another, those motives which crowd into consciousness and which find relatively easy introspective and verbal channels of expression must in some way be made to give place to the hidden, less easily accessible tendencies. Oftentimes, recall of the single episode which was in gross conflict with the major trends in the personality may enable the person to breathe again—to see the nature of the conflict which has been tearing him and to allow the struggling minority forces to retreat in good order instead of keeping up a futile fight This principle of recall of repressed material, however, rarely permits any such simple obvious removal of the trouble. It is rarely just *one* simple and obvious thing that has been kept out of mind. If, for example, a violent fear or disgust is ultimately traced to a frightening or disgusting situation in childhood which precipitated it, it is found that many other aspects of personality are involved in the conflict. Even if the

original symptom was not itself more than a reaction to a single disturbing stimulus, the chances are that the continuance of the maladjustment over a number of years has complicated it by allowing all sorts of other life interests and activities to become colored by the basic quality of fear or disgust, or even that fear or disgust has come to be a device unconsciously used by the person to get him out of difficulties.

PERSONALITY AND PHYSIQUE

Except for Jaensch's type theory (page 488), none of the views of personality described thus far have anything much to do with individual differences in bodily structure; and we have, in fact, raised doubt about the possibility of studying personality through anatomical characteristics. Yet several important contemporary views make much use of an approach via the facts of physique. Kretschmer believes, for example, that there is a definite physical type—with long spindle-like limbs—which is apt to be *introverted* (in Jung's sense); and it is from this type that definite "dementia præcox" or "schizophrenic" patients are drawn, with a tendency to a morbidly "shallow" emotional life and a habit of seclusiveness. Among the opposite type—with chubby, rounded features and limbs—are the emotionally intense but unstable persons (Jung's extraverts) who in extreme cases become sufferers from the "manic-depressive psychosis." Theoretically all human personalities incline in one direction or the other; those with a slight tendency toward the schizophrenic are called "schizoid," and those with a slight tendency toward the manic-depressive are called "cycloid." Such views, though they are too simple to fit the complicated facts, are useful in reminding us of the influence of constitutional factors in personality and suggesting the importance of close study of the interrelations between bodily traits and personality traits. The results in this field are, however, still very tentative and do not deserve emphasis.

SUMMARY

Behaviorism, as expounded by Watson, regards personality as a complicated pattern of habits, each of which is really just a conditioned emotional response. Janet emphasizes psychic tension which holds the parts of personality together; the lowering of psychic tension results in dissociation. Freud believes that struggle between sex tendencies and the ego results in conflict and repression, and that much adult behavior is governed by unconscious motives, against which the ego constantly defends itself. According to Freud, the whole personality can be understood only in the light of psychoanalysis, which permits the person to relive emotionally the experiences of his childhood. Jung believes that the basic drive is undifferentiated psychic energy, which at different times and under different conditions activates different forms of instinctive life. The direction in which the psychic energy is turned determines the extraversion or introversion of the individual For Adler the basic struggle is the effort to compensate for weakness, and the basic goal of all human beings is power. The style of life is the way in which the individual has formulated his goal, the kind of goal which he believes will give him power and security. All the theories of personality take into account the conflict between motives, and the necessity of grasping personality as a whole.

REFERENCES

Adler, A , *The Practice and Theory of Individual Psychology,* 1924.
Freud, S , *New Introductory Lectures in Psychoanalysis,* 1933.
Jung, C G , *Psychology of the Unconscious* (4th ed), 1927.
Watson, J B , *Behaviorism* (2nd ed), 1930.

PROBLEMS

1. After reading one of the recommended books, classify its contents in the following categories.

(a) doctrines based on critical analysis of all the available experimental and observational data,
(b) doctrines inherently reasonable but substantiated only by observation without adequate control of the observed situation,
(c) doctrines based on only fragmentary or casual observation;
(d) doctrines without any adequate substantiation of any sort, apparently representing simply the opinions of the author;
(e) doctrines based on evidence which is actually misused or distorted in the attempt to prove something

2 What kinds of data are yet to be collected before we shall be able to formulate an adequate theory of personality?
3. Make a strictly behavioristic study of the personality of a five-year-old child
4 Discuss the differences in meaning between the following statements:

(a) A man is not always conscious of his motives.
(b) Some of a man's motives are unconscious.
(c) Some of a man's motives are in the unconscious.
(d) Some of a man's motives are in his unconscious mind.

5. Make a character study of some person you know, with an exaggerated or "ingrowing" conscience, and show how Freud would explain this. How would Adler explain the same case?
6. How could Freud's theory of the origin of the ego be tested by experimental methods?

CHAPTER XXIV

PSYCHOLOGICAL "SCHOOLS"

ONE is often bewildered by popular books and articles presenting some theory or "school" of psychology. In these popular accounts one notes a tendency to oversimplify the subject matter of psychology. The unwary reader is left with the conviction that there is just *one* coherent, straightforward system of theories to which *all* psychological facts must conform. These theories are, moreover, supposed to be intelligible to any careful reader, yet the more reflective student feels humiliated at the discovery that he cannot really grasp what a given school is driving at Schools are not simple at all; even if they start with something clear and simple, they become more complicated as they come to grips with real psychological problems There is no harm in a simplification if it is clearly recognized as a simplification, and if the bareness of the outline is taken simply as a symbol of the desire for clarity. A greatly oversimplified view of the psychology of Janet, Freud, Jung, and Adler has already been given; these systems of thought might in a sense be called "schools of psychiatry" (of which there are many others).

This chapter will deal with some of the basic tenets of behaviorism (already briefly considered, pages 493-495), "existential" psychology, and Gestalt psychology. The memorizing of names and terms is not important except where it makes possible the clearer manipulation of ideas and permits a sort of shorthand designation of concepts which would otherwise require clumsy and long-winded terminology.

BEHAVIORISM

Behaviorism regards the subject matter of psychology as the behavior pattern of muscular and glandular responses. —As behaviorism is in some ways the simplest and most easily grasped of psychological schools, its doctrines will be stated first The behaviorist begins with the assumption that human beings are equipped with a considerable number of reflex arcs. If the neurologist with his little hammer elicits your reflexes, you will see how many specific responses there are which ordinarily would not be brought out in this precise and clear-cut way, independent of all other responses. Here the behaviorist points to two central facts: first, that nature provides us with a large number of simple units of action; second, that these units usually work in combination except where special technique can be used to separate them. Each of these reflexes can be called out by some specific stimulus. For example, swallowing is caused by fluid in the mouth. One might make a list of reflexes and the appropriate stimulation for each unit of action. There are some cases in which one stimulus may call out several different reflexes There are also many others in which a given reflex response occurs only as the result of the joint action of several stimuli.

By conditioning, any reaction unit or combination of reaction units can be called out by almost any stimulus. On the basis of behavioristic thought, all learning and all the more complicated aspects of human life can be treated as conditioned reflexes based upon the elementary reflex units. "Perception," "attention," "volition," etc, are regarded by the behaviorist merely as names for *complex muscular adjustments of the body* to external (and internal) stimuli Theoretically, the behaviorist has *no interest in experiences for their own sake*—even simple ones like the experiences of colors, or sounds, or feelings, but he studies the different muscular responses of his subjects, especially speech responses, when stimulated by physical color, sound, or pressure

It is necessary to emphasize that in many cases the response stimulates another response; that is, the muscular contraction also acts as stimulus. In the case of any skilled movement like playing the violin or tying one's shoes, each muscular contraction (which was originally called out by an appropriate external stimulus) has been trained to appear as the result of a preceding muscular contraction (cf page 252) We therefore find in the laboratory that a series of movements are run through in appropriate order, even when the skin is completely anæsthetized and external stimuli are shut out.

This is also a way of stating the behaviorist's theory of thought. Thought, for the behaviorist, is simply a series of muscular contractions of the speech organs (and other muscle groups), each pattern of contraction touching off some other pattern of contraction which was originally an appropriate response to an external stimulus, but which is now based on past experience (cf. page 334) A child doing mental arithmetic depends, of course, upon the rows of numbers which he has learned in the multiplication table This type of thinking involves a simpler kind of conditioning than *creative* thinking; the latter depends primarily upon the influence of muscular factors elsewhere in the body, which serve to shape or steer the thought processes. The purpose or mental "set" is really a muscular set, as a "hostile" attitude or a "friendly" attitude shows. The unstriped muscles and glands play their part, of course, along with the striped muscles.

Behaviorism is a doctrine for the explanation of mental processes in terms of physical processes. The behaviorist believes that mental processes are really just reflexes conditioned to one another; it becomes unnecessary to have a compartment for the separate discussion of the "mental life" as such. This is what the behaviorists mean when they say that terms like "consciousness" or "mind" merely obscure the issue. What they are concerned to do is to pattern their science upon biology, and to treat all mental events as physical responses in the body. To say that all psychologies recognize the importance of physical changes in the brain

does not satisfy them. The point the behaviorist wants to make is that the brain is nothing but the connecting station between the organs of response, i.e., the muscles and glands.

EXISTENTIAL PSYCHOLOGY

Existential psychology emphasizes the subject's experiences as directly known to the subject.—Introspective psychology, or, as it is usually called now, existential psychology, makes many of the same assumptions as behaviorism; for example, that psychology wants to be a natural science, to break up complex states and processes into simple ones, to analyze wholes into parts, and to understand each whole in the light of relations existing between parts which can be studied in isolation But existential psychologists are concerned not with behavior but with *experience.* Sensations, such as colors and tones as we experience them, are the primary data of experience These are supplemented, of course, by images (mental pictures, and so on) which serve as substitutes for the original sensations Images, however, are aroused in the mind by association. The doctrine of the "association of ideas" is simply a statement that all experience consists of sensations (or their residues, the images) connected with one another in various ways Some psychologists of this school give great importance to *feelings* of pleasantness and unpleasantness as a separate group of experiences; yet others assert these feelings to be so hard to distinguish from sensations as to make it probable that they are merely aspects of sensory experiences or make up a special kind of sensation

A great difference between existential psychology and behaviorism lies in the emphasis of the former upon attention. Attention contributes the quality of *clearness* which some sensations or images enjoy (cf. page 210) The actual course of mental life involves constant alteration in relative clearnesses. A conscious state is not the persistence of some one fixed entity, there is con-

stant alteration in consciousness, and the trained introspective observer must learn how to note and report it.

The behaviorist requires only a training in objective methods, and has little, if any, use for introspection. (He does, we saw, use "verbal reports," but if he is consistent he is concerned with the verbal response and not with the supposed mental event which the verbal response describes.) On the other hand, the existential psychologist requires a long training in the precise observation and description of experiences arising from laboratory stimulation, training which is offered at only a few American universities.

When experimental psychology was born, the psychologist assumed that his task was the experimental discovery and description of sensory elements and the study of the interrelations between such elements. The systematic exploration of the senses was the chief task of nineteenth-century experimental psychology. Helmholtz' great books on vision and audition were supplemented by a quantity of research on the lower senses and on the functions of nerve and muscle in relation to sensory stimulation. The laboratory for psychology at Leipzig, founded by Wundt in 1879, was primarily a laboratory for the study of sense perception. The direct influence of Fechner is seen in the attention given by Wundt not only to psychophysics, but to other problems in perception and judgment as well. Introspective psychology in the hands of Wundt had as its primary task the description of the nature of experience under certain limited and well-defined laboratory conditions. This kind of laboratory work necessarily involved the simplification and standardization of conditions of work; the helter-skelter of daily experience was too complex and too distracting to be systematically explored in the scientific spirit. The phenomena of color contrast or the qualitative characteristics of the memory image may reveal something of themselves in daily life, but what they reveal is fleeting, unstable, and uncertain, and the reports of casual observers fail to agree. It became necessary, therefore, even at the price of narrowness, to define more and more strictly what kinds of problems may profitably be approached and what kinds of qualities of experience may be adequately investigated.

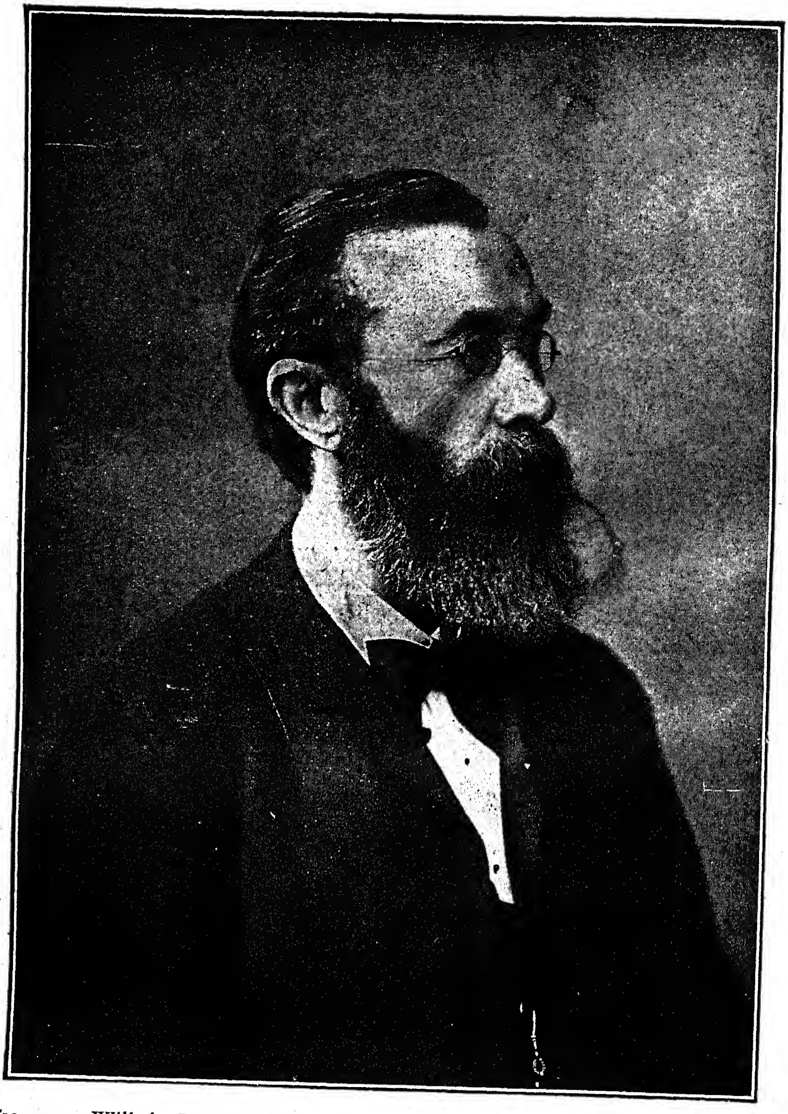


FIG. 119.—Wilhelm Wundt, founder of the first psychological laboratory. Photograph by courtesy of J. McK. Cattell.

GESTALT

Gestalt psychology emphasizes the indivisible unity of each response of an organism.—Throughout the discussion of the two preceding schools it has been assumed without argument that scientific method always works from parts to wholes. The first problem of science is considered to be the discovery of the parts of which a thing is made, and of the relations between the parts. The whole is supposed to be entirely explained if the parts and the ways in which they are put together are clearly defined. The atomic theory which was accepted in chemistry a century ago was an explicit statement as to the way in which compounds were to be explained; the molecule was to be resolved into atoms which were thought of as indivisible units. The task of the chemist was to find all the elements and to understand all compounds in terms of the characteristics of the elements and the ways in which they were put together. The immense success of this viewpoint in chemistry gave hope that something similar would be found in biology. Sure enough, before many decades had passed, biologists found that all animals and plants were made up of cells, and saw that the life principles of plants and animals could be seen in terms of the basic laws of life in the cell and the ways in which the cells were put together. Of course more recent years have witnessed the discovery that the chemist's atom is really a complex structure which needs to be broken up still further, and the biologist emphasizes that the cell can in many ways be analyzed into finer elements. The fact remains, however, that the chemist, starting from atoms, and the biologist, starting from cells, could make the laws of large patterns depend upon laws which had been learned from the study of relatively small and simple parts. Whatever the elements which are fashionable in science in any given age, they must necessarily be considered at the time as fixed and unchanging. They are like bits of a mosaic whose absolute fixity of character is the first thing to be accepted by anyone who wishes to create a

mosaic pattern. Similarly, if the cell ceases to be a cell when many cells are put together in a living thing, then the concept of the cell as an element is meaningless. It is necessary that each element should stay put and maintain the same characteristics if any whole pattern is to be explained by reference to such elements. All this seemed self-evident to most scientists in the last century.

Nevertheless, rebellion against this whole mode of thought has shown itself in all the sciences in recent years, particularly in physics, in chemistry, and in biology. The characteristics in which compounds differ from one another are often found to be incapable of prediction even when the chemist states rather fully the nature of the elements and the way in which the elements are combined. At least for the present, it is more profitable to know that wholes or compounds have properties which no one could have predicted from a knowledge of the parts, or even of the parts plus the patterns in which the parts are combined. There is a suspicion also that even the parts actually depend in large degree upon the organization in which they appear. It is possible that the parts reflect the organization of the whole. The same general principle is true in biology There is much discussion nowadays of "emergence," which means simply the appearance of characteristics in animals or plants which are not predictable at all from a knowledge of their physical and chemical make-up or even of the way in which the cells are put together. The doctrine of "emergent evolution" teaches that nature is constantly producing genuinely new living forms. A true creative process is at work. Not, of course, that nature is making something out of nothing, but that she hits upon combinations of old parts which give a new quality which could in no way be guessed from a knowledge of the qualities of the parts. Even a complete quantitative understanding of the chemistry of the cell and of the pattern of the whole body—both of which are very far from being understood at present—would still leave qualities which are neither chemical nor anatomical, namely, dynamic aspects of the life of the organism which express something truly unique in the history of life on this planet From this point of

view, the whole possesses not only properties different from those of its parts, but properties which must be understood before the parts themselves can be fully understood. Cells which are put together in a particular way produce an organism which is literally a new creature, and if we study closely the life of the new creature we shall find that even the individual cell is different from any preceding cell because it depends upon the new kind of organism in which it appears.

Protest against atomism in psychology has arisen for the same reasons. Compare the experiments of Wertheimer in 1912 and of the "*Gestalt*" school of psychology which has arisen from the work of Wertheimer and his pupils (The word *Gestalt* is roughly equivalent to *form* or *pattern.*) For example, let light be flashed through a narrow slit and, about a half second later, through a slit inclined at an angle, as shown in Fig 120 The observer sees one light, then another Let the interval between the two exposures be reduced to 1/40 of a second; there is a moment at which the two streaks of light are seen simultaneously. However, let the time interval be varied between 1/40 of a second and a half a second; a point will be found at which the observer sees the first shaft of light as falling to the right, as shown by the arrow, although nothing really does fall. What are we to think of this? According to the classical doctrine of perception, we receive through our sense organs particles or patches of experience, such as blotches of red, blasts of noise, jabs of pain. From these elementary sense qualities we build up patterns or wholes, that is, we perceive. Perception is the association of a number of sense experiences with one another. Many sensations make one percept. Even writers who emphasize the dynamic unity of the mind and the necessity of emphasizing an act of integration when given a percept, still speak as if the sense elements remain

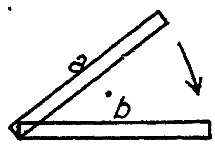


FIG. 120 —Perception of apparent movement If the experimenter flashes light through slit *a*, follows this by a dark interval of about one-twentieth of a second, and then flashes light through slit *b*, a shaft of light seems to fall in the direction of the arrow.

absolutely constant as they pass from the condition of being *nothing but sensations* to the condition of being parts of a *perceptual whole.* The sense impressions, in other words, are elements. They know how to behave, so to speak, when they are in company, and know that in company their task is to remain in character, that is, not to change at all from what they were when alone. The visual perception of motion is therefore thought of as depending upon the stimulation of separate points on the retina. The stimulation of separate points on the retina, if given in the correct order, should give a perception of motion. If an object swings across in front of us it makes a track of light on the retina The path over which it moves is made up of a series of points from each of which stimulation is received Let the eye, for example, be fixed upon a yellow pencil held vertically and let the pencil fall to the right; a patch of yellow light falls on the retina, its length and width dependent upon the length of the pencil and the distance through which it falls. In this case the perception of motion depends upon the sum of a large number of sensory impressions received from the pencil in its various successive positions Some authors consider a percept a rather passive thing, an impression which an object makes on us; others emphasize the unifying activity of the mind in the process of integrating the separate elements Both groups of authors, however, speak as if unification or synthesis keeps the elements in the same state in which they have been The separate visual sensations are unified when we see a thing move, but each remains throughout the process the sensation that it always has been

All this is denied by the Gestalt psychologist. The perception of motion comes *directly.* In the experiment cited there never was any actual motion across the retina, and no independent sensory elements which could be compounded to give this total effect. A *percept* is an *indivisible whole.* Every mental state must be taken for what it is as a whole, not as a compound of hypothetical *elements.*

The Gestalt psychologist uses these same principles in the study of learning. The notion of independent reflex acts has seemed to

him as useless as the notion of independent sensations. He has been interested to follow the implications of the view that organisms behave literally as organisms, not as agglomerations of independent units of action The basic notion of trial-and-error movements from which, by piecemeal conditioning, separate parts are fixated and stuck together in a sequence to give the pattern of a skilled act has seemed to him a travesty upon the process by which men or animals learn. For the most part, an animal in a maze has had no choice but to behave as an automaton. As the tasks are made more complex, however, there is more and more evidence that these animals grasp patterns or totalities. The higher animals exhibit the tendency to take in whole situations just as little children do. Perhaps the most distinctive thing about the learning process is the tendency of organisms to jump from one type of total response to another. The entire pattern shifts from moment to moment. One cannot, in order to try out a new reaction, hold ninety-nine parts of the organism constant while one part varies.

Gestalt psychologists have also inquired regarding emotion, will, and personality, for the most part insisting that these and all other psychological concepts can be made more fruitful if they are regarded as ways in which the organism as a whole responds, rather than as special sequences of response within certain parts of the body. One illustration only need be given, namely, Lewin's study of the expansive and retractive behavior shown in intense emotion Everyone knows in a general way that pride usually involves a literal expansiveness, a literal stretching out of hands, swelling of the chest, throwing back of the head, in such a way that the individual actually seems to fill more space. The subdued or embarrassed individual seems to contract, the head falls forward or toward the chest, the hands are drawn in, falling limply into the lap if one is sitting down, tending to be drawn closely toward the trunk if one is standing Lewin's photographs bring out what he calls the dynamic characteristics of these emotions. The detailed changes in the body—acceleration of the pulse, drooping of the eyelids, etc.—are regarded by him as of minor

concern. It is the *pattern*, or Gestalt, of the expressive behavior *as a whole*, that is of chief interest and importance.

Each of these schools has something important to contribute, but none is the last word.—These schools, and the other psychological schools not mentioned here, have originated in the desire to *systematize* psychology The fact that psychologists disagree as to the merits of these systems is evidence that the data of experimental psychology do not as yet justify the dogmatic acceptance of a rigid system. Some of the unifying laws of a future psychology will undoubtedly be found to depend upon physiological laws. In fact, most psychologists believe that the systematization of their science will depend chiefly upon the progress made in systematizing physiology and other biological sciences At any rate, we can be absolutely certain that all the attempts to systematize psychology on the basis of our *existing* information have resulted in oversimplified and misleading formulations.

The schools have contributed useful and vital hypotheses and points of view, but they all have tended toward one-sidedness It is idle to protest against schools, or to plead, in a negative sort of way, for tolerance The tendency to prefer reasonably clear, well-organized, and dogmatic systems of thought to the more complicated and often indefinite systems which are characteristic of scientific caution is but human. Not only our curiosity, but our aversion to the tension which suspended judgment involves, makes loyalty to one school the easiest path to choose Furthermore, we actually *need* schools, simply because our subject matter is so complicated; schools force us to consider bold general hypotheses which help to organize and systematize facts and are an indispensable part of scientific progress. If such hypotheses tend to be stated in dogmatic form, that is, after all, the price we have to pay. The ultimate reconciliation of the schools, and the ultimate systematization of psychology on a sound basis, will surely come through the improvement and extension of psychological methods—especially methods of experimenting and measuring.

All the schools make use of the experimental method; experimentation will ultimately bring the schools nearer together.—Two general facts strike the observer: first, that *experimental* methods have been applied in one new field after another—first sensation, then memory, then reasoning, then emotion, then character, etc. Second, as regards the use of *quantitative* devices, practically all truly scientific information is in quantitative form. You may love the stars as objects of beauty, but to know them scientifically you have to think in terms of spectroscopic analysis, parallax, speed of motion, and so on. You may dread an infectious disease, but in order to cope with it you must consider (or the bacteriologist must consider for you) surface tensions, rates of multiplication, lethal temperatures, and the like. Similarly, in psychology, though the best preliminary analysis may be made from a qualitative point of view, or even from a "literary" or "intuitive" point of view, the discovery of genuine psychological laws is almost certain to lead to measurement and the formulation of quantitative laws

The reader may note many cases in which qualitative realities were found capable of quantitative measurement. Even the Gestalt psychology and psychoanalysis, beginning with the qualitative study of mental phenomena, have tended in the last few years to find ways of stating their conclusions in quantitative terms. This does not, of course, mean that the mathematical equation takes the *place* of the original qualitative statement, any more than use of a spectroscope replaces direct observation of the stars. It was Fechner's conviction that the world of measurements and the world of direct experience are ultimately the *same* world which we know in two different ways, and that an exact quantitative psychology will be one way of approaching the same subject matter which we approach "intuitively" in everyday life.

Even such a general statement as this must be offered cautiously. The chief weakness of psychology, its lack of organization and the uncertainty as to the direction in which it is going, is at the same time its chief fascination. How far it will go will probably be judged in terms of one's own estimate of scientific method in

other fields of life An extraordinary change has been wrought in our material civilization in three centuries as a result of scientific modes of thought in the physical sciences, an attempt at scientific psychology has been with us only a short time Its subject matter is probably more difficult to study scientifically than is that of any other science, but, on the other hand, we can gratefully utilize many of the general principles of scientific method discovered in all sciences.

Our estimate of what psychology can do will depend partly on these considerations and partly on social and economic developments, upon which, of course, all scientific research ultimately depends.

SUMMARY

While behaviorism emphasizes the objective study of behavior, existential psychology is directly concerned with the description and analysis of experiences as they are known to the subject Gestalt psychology studies both behavior and experience, but denies the necessity of starting with simple elements, preferring to look for whole responses of the organism These and other schools have valuable hypotheses to offer, but the sharp differences between them will gradually disappear as improved methods result in the scientific systematizing of the whole field of psychology.

REFERENCES

Dashiell, J. F, *Fundamentals of Objective Psychology,* 1928.
Koffka, K, *The Growth of the Mind,* 1924
Kohler, W, *Gestalt Psychology,* 1929
McDougall, W., *Outline of Psychology,* 1923
Murchison, C (Ed), *The Psychologies of 1930.*
Titchener, E B, *Textbook of Psychology,* 1910
Watson, J B, *Psychology from the Standpoint of a Behaviorist* (3rd ed), 1929
Woodworth, R S, *Contemporary Schools of Psychology,* 1931

PROBLEMS

1. List the ways in which "schools" contribute to the advance of a science like psychology and the ways in which they interfere with its progress
2. If you were interested to found a psychological department in a new university, would you pick men who had been identified with different schools, or representatives of one school (and if so, which one), or representatives of no school? Why?
3. What are the differences and the similarities between psychological schools and religious sects? To what extent do the different groups in each case put legitimate emphasis on different aspects of reality, and to what extent are they held together by logically irrelevant factors which you could name?
4. How would behaviorism and existential psychology differ in the study of language?
5. Why do you suppose the term "behaviorism" is often loosely used to mean "materialism"?
6. How could a behaviorist describe attention?
7. What relation is there between Gestalt psychology and the fact that "no gland ever functions in isolation"?
8. What are the chief "blind spots" of psychologists? What important problems do they constantly overlook? How might these problems be studied?
9. What is the most valuable thing you have gained from the course? In what way could the course have been more suited to your needs?
10. Would you be willing to take a retest on the subject matter of this course one year after completing it, so that the instructor might form an opinion as to how well the material has been presented and how well it sticks? How much do you think you will remember five years from now?

REFERENCES

Figures in the first column refer to page; in second, to paragraphs, in third, to line. When any citation of experimental fact takes more than one line, the reference given here is to the line in which the statement ends Convenience rather than consistency, however, has been sought, and when a paragraph introduces an entirely new type of material the first line of the reference is taken as the reference point. The material at the top of each page, until the paragraph ending is reached, is always considered paragraph 1

The letters "Cf." at the beginning of a reference mean that it will be of interest to compare the text with the reference, but not that the statement in the text is taken *directly* from the reference.

Key to abbreviation of periodicals

A. J.—American Journal
A. J P.—American Journal of Psychology
Arch. P.—Archives of Psychology
C P M.—Comparative Psychology Monographs
G. P M —Genetic Psychology Monographs
J Abn & Soc P.—Journal of Abnormal and Social Psychology
J Appl. P —Journal of Applied Psychology
J. C. P —Journal of Comparative Psychology
J. Ed. P —Journal of Educational Psychology
J. Exp. P.—Journal of Experimental Psychology
J Gen. P —Journal of General Psychology
J Genet P.—Journal of Genetic Psychology
P B —Psychological Bulletin
P. R —Psychological Review
P. R Monog —Psychological Review, Monograph Supplement

Chapter I

4	2	11	Cf Tylor, E B , *Primitive Culture,* Holt, '74, i, 440 ff.; Lowie, R H , *Primitive Religion,* Boni, '24, chap v.
		21	For the influence of the orphic tradition upon Plato, see Dessoir, M , *Outlines of the History of Psychology* (trans by D Fisher), Macmillan, '12, 1-15
6	2		In connection with the whole paragraph, cf. Boring, E G , *A History of Experimental Psychology,* Appleton-Century, '29
		32	Ebbinghaus, H , *Memory* (trans. by H. A Ruger and C E Bussenius), Teachers College, '13.
7	1	1	Cf Boring, E G , *History of Experimental Psychology,* 395-399, Titchener, E B , *Lectures on the Experimental Psychology of the Thought-Processes,* Macmillan, '09
		2	Cf Hartshorne, H , and May, M A., *Studies in the Nature of Character. I. Studies in Deceit,* Macmillan, '28

8	2	1	Cf Watson, J B, *Psychology from the Standpoint of a Behaviorist,* Lippincott, 3rd ed rev, *Behaviorism,* Norton, rev. ed.
11	1	11	Cf Jones, M C, in *The Child's Emotions,* Univ of Chicago Press, '30, 42 ff
	3	13	Cf Goodenough, F L., *Developmental Psychology,* Appleton-Century, '34, Stoddard, G D, and Wellman, B L, *Child Psychology,* Macmillan, '34
12	1	1	Cf. Hollingworth, H L, *Abnormal Psychology,* Ronald, '30, Dorcus, R M, and Shaffer, G W., *Textbook of Abnormal Psychology,* Williams and Wilkins, '34
		6	Cf. Washburn, M F., *The Animal Mind,* Macmillan, 3rd ed, Warden, C J., Jenkins, T. N, and Warner, L H, *Introduction to Comparative Psychology,* Ronald, '34
		11	Cf Allport, F. H, *Social Psychology,* Houghton, '24, Folsom, J K, *Social Psychology,* Harper, '31, Murphy, G and L B, *Experimental Social Psychology,* Harper, '31
		13	Cf. Poffenberger, A T, *Applied Psychology,* Appleton-Century, '27, Husband, R W, *Applied Psychology,* Harper, '34, Viteles, M S, *Industrial Psychology,* Norton, '32
		14	Cf Jordan, A M, *Educational Psychology,* Holt, 2nd ed, Pressey, S L, *Psychology and the New Education,* Harper, '33.
		17	Cf Griffitts, C H, *Fundamentals of Vocational Psychology,* Macmillan, '24, Hollingworth, H L, *Vocational Psychology and Character Analysis,* Appleton-Century, '29
		18	Cf Roback, A A, *The Psychology of Character,* Harcourt, '27.

Chapter II

17	3		For general reference, cf Dendy, A, *Outlines of Evolutionary Biology,* Constable, 3rd ed
18	2	12	Cf Yerkes, R M and A W, *The Great Apes,* Yale Univ Press, '29
19	1	5	Cf Osborn, H F, *Men of the Old Stone Age,* Scribner, 3rd ed, '18, MacCurdy, G G *Human Origins,* Appleton-Century, '24, 1
	3	2	Jennings, H S, *Behavior of the Lower Organisms,* Columbia Univ Press, '31, 17 f
20	1		In connection with the whole paragraph, cf Kohler, W, *The Mentality of Apes* (trans by E Winter), Harcourt, '25, appendix
		12	*Ibid*, 306
	2	9	Cf. Du Chaillu, P. B *Explorations and Adventures in Equatorial Africa,* New York, '61; Barns, T. A, *Across the Great Craterland to the Congo,* London, '23
		10	Cf Yerkes, R M, *Almost Human,* Appleton-Century, '25
		18	Kohler, W, *The Mentality of Apes,* 295 ff.
21	3	9	Cf Yerkes, R M and A W, *The Great Apes,* 162 f, 302 ff
	4	12	Kellogg, W N and L A, *The Ape and the Child,* McGraw-Hill, '33, chap xii
22	1	9	Cf Squires, P C, *A. J. P.,* '27, 38 313-315, Kellogg, W N, *A. J P.,* '31, 43 508-509.
23	1	15	Cf Starr, M A, *Organic and Functional Nervous Diseases,* Lea and Febiger, 4th ed, '13, 61
25	1	6	*Henry IV, Part I*
		8	*Iliad,* bk 1, see description of Thersites

26 1 7 Weismann, A, *The Evolution Theory* (trans by J. A. and M. R. Thompson), Arnold, '04, ii, 65

28 2 21 Cf Beaglehole, E, *Property,* Macmillan, '32.

29 1 2 Cf. Osborn, H F, *Men of the Old Stone Age,* chap iv ff.

3 On the whole subject of heredity, see Morgan, T. H, *The Physical Basis of Heredity,* Lippincott, '19 For condensed statement, see Murchison, C. (ed), *A Handbook of General Experimental Psychology,* Clark Univ. Press, '34, chap ii by T H Morgan.

30 2 3 Cf Morgan, T H, *The Physical Basis of Heredity,* 247 ff

31 2 2 Cf Morgan, T H, *The Theory of the Gene,* Yale Univ. Press, rev ed, 300.

21 Cf Muller, H J, *Proc Nat. Acad. Sci.,* '28, 14 714-726

32 3 18 Cf Parker, G H, *The Elementary Nervous System,* Lippincott, '19, chaps. ii, iii

33 2 5 *Ibid,* 152 ff., cf also Parker, T. J, and Haswell, W. A, *A Textbook of Zoology,* Macmillan (London), 3rd ed., i, 39 f.

Chapter III

36 2 5 Cf Tilney, F T, and Kubie, L. S, *Bull. Neurol. Inst,* New York, '31, 1 235

37 1 7 Coghill, C E, *Anatomy and the Problem of Behavior,* Macmillan, '29

2 11 Carmichael, L., *P R,* 527, 34 34-47

39 2 12 Avery, G T, *G P M,* '28, 3 245-331

40 1 5 Cf Irwin, O C, *G P. M.,* '30, 8 1-92.

10 Cf Pratt, K C, Nelson, A K, and Sun, K H., *Ohio State Contrib. to Psychol,* '30, no 10

17 Cf Irwin, O C, *G P M,* '30, 8 1-92

2 10 Cf Shirley, M M, *The First Two Years,* Univ of Minn Press, i, '31, ii, iii, '33

47 1 29 Sherrington, C S, *The Integrative Action of the Nervous System,* Yale Univ Press, '06, chap. viii.

48 1 2 *Ibid,* 114

2 13 *Ibid,* 106 ff, 292 ff

Chapter IV

53 2 11 Wada, T, *A P,* '22, 8, no 57

3 2 Cannon, W B, and Washburn, A L, *A J. Physiol,* '12, 29 441-454

54 1 5 Cf Rogers, F T, and Hardt, L L J, *A. J. Physiol,* '15, 36 183 ff

3 5 Bulatao, E, and Carlson, A J, *A J Physiol,* '24, 69 107-115, La Barre, J, and Destrée, P C, *Rev. soc de biol,* '30, 103 532-533 For negative evidence, see Quigley, J P, and Templeton, R D., *A. J., Physiol,* '30, 91 475-478

13 Carlson, A J, *The Control of Hunger in Health and Disease,* Univ of Chicago Press, '16, 219-220.

55 1 8 Bayer, E, *Zsch f Ps,* '28, 108 120-125, reported in Katz, D, *Univ. of Maine Studies,* '30, 2nd series, no 14, 17

2 2 Richter, C P, *Quart. Rev. Biol,* '27, 2 307-343.

6 Schiff, *Physiologie de la Digestion,* Florence, '67, i, 41, reported in Cannon, W. B, *v infra,* Cannon, W. B, *Bodily Changes in Pain, Hunger, Fear and Rage,* Appleton-Century 2nd ed, 308 ff

		11	Cf. *ibid.*, 306 f
56	1	2	*Ibid.*, 321 ff.
	2	21	Cf. Richter, C P, *Quart Rev. Biol.*, '27, 2 307-343.
57	2	3	Wang, G. H, *C. P M.*, '23, 2, no. 6, Warner, L H, *C. P M.*, '27, 4, no 22, Nissen, H. W, *G P. M*, '29, 5 451-547
		5	Richter, C. P, *Quart Rev Biol.*, '27, 2 307-343
		11	Richter, C P, *Amer J. Orthopsychiat.*, '32, 2 345-354.
58	2		On the whole subject of internal secretions, see Hoskins, R G, *The Tides of Life*, Norton, '33, Sharpey-Schafer, E, *The Endocrine Organs*, Longmans (London), '24
59	1	16	Cf. Stone, C. P., *J C P*, '26, 6 73-83, *J. Exp. P*, '23, 6 85-106, *J. C. P.*, '23, 3 469-473
60	1	5	Cf. Stone, C P, and Sturman-Hulbe, M, *J C P*, '29, 9 203-237
61	3		On the whole subject of sex gland secretion, cf. Lipschutz, A, *The Internal Secretions of the Sex Glands*, Williams and Wilkins, '24.
	4	4	Cf. Thorek, M, *Endocrinology*, '24, 8 69-90.
62	1	5	Cf Stone, C P, *J. C. P.*, '22, 2 95-153
	2	4	Cf Sharpey-Schafer, E, *The Endocrine Organs*, 12, 60 ff, 166 ff, 313 ff, 412 ff
		5	Cf Hoskins, R G, *The Tides of Life*, 246 ff
		8	Cf. Harris, J A, Jackson, C M, Paterson, D G, Scammon, R E, *The Measurement of Man*, Univ of Minn. Press, '30, 200
63	2	9	Cf Sherrington, C S, *The Integrative Action of the Nervous System*, 329 ff.
		26	Cf. Craig, W, *Biol. Bull*, '18, 34 91-107
65	1	3	Cf Warden, C J, *Animal Motivation*, Columbia Univ Press, '31, 383 ff.
	2	3	Cf. Woodworth, R S, *Psychology, A Study of Mental Life*, Holt, 1st ed, 180-184
	3		On the whole paragraph, cf McDougall, W, *An Introduction to Social Psychology*, Luce, 12th ed, Thorndike, E L, *The Original Nature of Man*, Teachers College, '13, Woodworth, R S, *Dynamic Psychology*, Columbia Univ Press, '18, Allport, F H, *Social Psychology*, Houghton, '24, Bernard, L L, *An Introduction to Social Psychology*, Holt, '26
66	1	20	Cf Thorndike, E. L, *P R Monog*, '01, 3, no 15
68	1	2	Cf Thorndike, E L, *The Original Nature of Man*, 88 ff.
		7	Cf. Allport, F H, *Social Psychology*, chap iii
		15	Cf. Freud, S, *Collected Papers* (trans by J Riviere), Woolf, '25, iv, 30-59

Chapter V

71	2		In connection with the entire discussion on pp 71-77, cf Cannon, W B., *Bodily Changes in Pain, Hunger, Fear, and Rage*, *The Wisdom of the Body*, Norton, '32, *Feelings and Emotions · The Wittenberg Symposium*, Clark Univ Press, '28, 257-269
72	2	7	Cannon, W B, *Bodily Changes*, 12 ff
		11	*Ibid.*, 93 ff
		13	*Ibid*, 8 ff
	4		In connection with the whole problem of the autonomic nervous system, cf Kuntz, A, *The Autonomic Nervous System*, Lea and Febiger, '29

75	1	18	Cf. Sharpey-Schafer, E, *The Endocrine Organs,* i, 100 ff ; Cannon, W. B, *Bodily Changes,* 80 ff
77	1	2	Gleason, J, *P. B,* '26, 23 163-164
	3	3	Lange, C G, *Uber Gemuthsbewegungen* (trans. by H Kurella), Leipzig, '87, James, W, *Mind,* '84, 9 188-205. Reproduction of these articles is to be found in Dunlap, K. (ed), *The Emotions,* Williams and Wilkins, '22. Or see James, W., *The Principles of Psychology,* '90, ii, chap xxv.
79	3	4	Cf D'Allones, G R., *Rev. Phil.,* '05, 60 592-623
80	1	8	Sherrington, C. S, *Proc Roy Soc, London,* '00, 66 390-403, reported in Sherrington, C S, *Integrative Action of the Nervous System,* 260 ff
		11	Cannon, W. B, Lewis, J T, and Britton, S. W, *Boston Med. and Surg. J,* '27, 197 514-515.
81	1	6	Cf. Goltz, F., *Pfluger's Arch,* '92, 6, reported in Sherrington, C S, *Integrative Action of the Nervous System,* 262 ff.
		25	Head, H., and Holmes, G, *Brain,* '11-'12, 34 102-254.
82	2	7	Bard, P, *P. R.,* '34, 41 309-329, 424-449
83	3	9	Cf Cantril, H, and Hunt, W. A, *A. J P.,* '32, 44 300-307.
		11	Cf. Marañon, G, *Rev fr. d'endocrinol.,* '24, 2 301, reported by Cannon, W B, *Bodily Changes,* 356 f.
		15	Cantril, H, and Hunt, W A, *A. J. P.,* '32, 44 300-307
84	2		Blatz, W E, *J. Exp P,* '25, 8 109-132
86	4	1	Cf Pratt, K C, Nelson, A K, and Sun, K H, *Ohio State Contrib. to Psychol,* '30, no 10.
87	1	5	Cf Watson, J B, *Psychology from the Standpoint of a Behaviorist,* 270, 276.
		7	*Ibid,* 270, 273
		10	*Ibid,* 270-272.
	2	5	*Ibid.,* 241 ff.
88	1	28	Sherman, M and I C, *The Process of Human Behavior,* Norton, '29, chap v
89	2	7	Goodenough, F. L, *Child Develop.,* '31, 2·96-101.
		12	Goodenough, F L, *J Abn. & Soc. P,* '32, 27 328-333.
90	2	5	Landis, C., *J. Exp P,* '24, 7 325-341, *J. C P.,* '24, 4 447-509
		20	Landis, C, *J Exp. P,* '24, 7 325-341, *J. Gen. P,* '29, 2 59-72
95	1	15	Cf Allport, F H, *Social Psychology,* chap ix, also Guilford, J P, *J Abn. & Soc P,* '29, 24 192-202.
97	2	4	Cf Shepard, J F, *A J P,* '06, 17 522-584
		10	Cf Smith, W W, *The Measurement of Emotion,* Harcourt, '22 See also Wells, F. L, and Forbes, A, *Arch P,* '11, 2, no 16
	3	4	Cf Titchener, E B, *Lectures on the Elementary Psychology of Feeling and Attention,* Macmillan, '08
		9	*Ibid.,* 46 ff.

Chapter VI

103	2	5	Cf Blatz, W E, *J. Exp P,* '25, 8 109-132 See also Landis, C, and Slight, D, *J Gen. P,* '29, 2 413-420
		14	Cf Chappell, M. N, *Arch P,* '29, 17, no 105.
105	2	3	Cf Skaggs, H. E, *J C P.,* '26, 6 303-318

		16	Cf Landis, C, and Wiley, L E, *J. C. P.*, '26, 6 1-19, also Chappell, M. N., *Arch. P.*, '29, 17, no 105
107	2	4	For general discussion, cf. Landis, C. and De Wick, A N, *P. B*, 29, 26 64-119 For detailed study, cf Bayley, N, *P. R Monog.*, '28, 38, no. 176, 1-38
109	2	5	Cf Landis, C, *P. R*, '30, 37 381-398
		7	Cf Aveling, F, in *Feelings and Emotions, Wittenberg Symposium*, 49-57, *Brit. J. P*, '25, 16 50-52
111	1	2	Wells, F L., and Forbes, A, *Arch. P*, '11, 2, no 16.
	2	7	Darrow, C. W., *J Exp P.*, '27, 10 197-226.

Chapter VII

114	3	7	Cf Forbes, A, in Murchison, C (ed), *A Handbook of General Experimental Psychology*, Clark Univ. Press, '35, 169 ff For experimental evidence, see Adrian, E. D, *J Physiol.*, '14, 47 460-474
115	1	4	Cf. Adrian, E D, *The Basis of Sensation*, Norton, '28, also Adrian, E. D, and Brouk, D W, *J Physiol*, '29, 67 119-151
116	1	3	Cf Wever, E G, and Bray, C. W, *P R*, '30, 37 369, 379
	3	3	Muller, J, *Handbuch der Physiologie der Menschen*, Holscher, Coblenz, 1840, ii, bk v, reported in Boring, E G, *A History of Experimental Psychology*, 77-87 See also Rand, B., *The Classical Psychologists*, Houghton, '12, 530-544
		6	Cf Rand, B, *The Classical Psychologists*, 542
120	3	12	Cf Ranson, S W, *Science*, '33, 8 395-399
	4	5	Burnett, N. C, and Dallenbach, K M, *A J P.*, '27, 38 418-431 28, 40 111-117.
122	1	2	Burnett, N. C, and Dallenbach, K M, *A J P*, '27, 38 418-431. Cf. also Koch, M, *A J P*, '32, 44 800
125	1	2	Cf Katz, D, *Univ. of Maine Studies*, '30, 2nd series, no 14, 100
	2	6	Sullivan, A H, *J Exp P*, '27, 10 447-462
126	1	6	Goldscheider, A, *Gesammelte Abhandlungen*, Barth, '98, ii, reported in Ladd, G T, and Woodworth, R S, *Elements of Physiological Psychology*, Scribner, '11, 364
		10	Ladd, G T, and Woodworth, R S, *op cit*, 409
	2	7	Lashley, K. S., *A. J Physiol*, '17, 43 161-194
	3	10	Henning, H, *Der Geruch*, Barth, '24
127	2		Cf Crozier, W J, in *A Handbook of General Experimental Psychology*, 1001
128	2	29	Cf. Nagel, W, *Handbuch der Physiologie*, Vieweg, '05, iii, 611, also Ladd, G T, and Woodworth, R S, *Elements of Physiological Psychology*, 306 f.
129	1	11	Frisch, K, von, *Zool. Jahrb Abt. f. Physiol.*, '19, 37 1-238, reported in Crozier, W J, *A Handbook of General Experimental Psychology*, 998
		18	Cf. Rivers, W H. R, *Brit. J. P*, '05, 1 321-396

Chapter VIII

132	1	5	Hahn, W L, *Biol Bull*, '08, 15 165-193
		10	Cf Katz, D, *Univ of Maine Studies*, '30, 2nd series, no 14, 100
	3	4	Cf Vance, T. F., *P. R Monog*, '14, 16, no 69, 104-114, also Wegel, R L, *Proc Nat Acad Sci*, '22, 8, no. 7.

133	1	2	Cf Wegel, R L, *op. cit* For summary statement, see Banister, H, *A Handbook of General Experimental Psychology,* 884, also Fletcher, H, *Speech and Hearing,* Van Nostrand, '29, 142 ff
		16	Cf Gough, E, *Arch P.,* '22, no 47; Petrau, L A, *P. R. Monog.,* '32, 42, no 193
136	1	3	Cf Davis, H, in *A Handbook of General Experimental Psychology,* 976, *A J. Physiol,* '34, 107 311-332, Wever, E. G, *Physiol. Rev,* '33, 13 400-425
138	2	14	Helmholtz, H L F, *On the Sensations of Tone* (trans. by A J Ellis) Longmans, 4th ed, part 1, chap v, 119 ff
139	2	4	Cf Metfessel, M, *Univ of Iowa Studies in Psychology of Music,* '32, 1 14-117, Tiffin, J, in *ibid,* 1 134-165
		7	Metfessel, M, *op cit.,* cf also Shoen, M., *P. R. Monog.,* '22, 31, no. 140, 231-259.
		9	Metfessel, M, *op. cit,* 104 ff
	3	5	Metfessel, M., *P. R Monog.,* '26, 36, no 167, 1-40, cf also Tiffin, J, *Univ. of Iowa Studies in Psychology of Music,* 1 118-133
		8	*Ibid*
140	2	2	Young, P. T, *J. Exp P.,* '28, 11 399-429
141	1	2	*Ibid* Cf also Young, P T, *J Exp P,* '31, 14·95-124
	2	3	Helmholtz, H L F, *On the Sensations of Tone,* part 1, chap. vi, 142-151
	3	9	Cf Hartridge, H, in *A Handbook of General Experimental Psychology,* 934 f
142	1	14	Cf Wever, E G, and Bray, C W, *P. R,* '30, 37 365-380, also Hartridge, H, in *A Handbook of General Experimental Psychology,* 932 f

CHAPTER IX

144	3	8	Zigler, M J, Cook, B, Miller, D, and Wemple, L A., *A. J. P,* '30, 42 246-259
146	2	3	Helson, H., *A J. P,* '29, 41 345-397. For contrary evidence, cf Garvey, C R., *J Exp. P.,* '33, 16 83-97. For Helson's reply, see Helson, H, *J Exp P,* '34, 17 763-772.
	3	7	Cf Hecht, S, *J. Gen Physiol.,* '19-'20, 2·449-512, reported in Troland, L T, *The Principles of Psychophysiology,* Van Nostrand, '30, ii, 96 f
149	3	17	Cf Ferrel, C E, and Rand, G., *P R,* '19, 26·16-41; *ibid,* '20, 27 1-23.
		18	*Ibid*
150	2	6	Newhall, S M, and Dodge, R, *J Exp P,* '27, 10 1-17.
151	2	2	Cf Staples, R, *J Exp P,* '32, 15 119-141, also Garth, T. R, *Race Psychology,* McGraw-Hill, '31, 115-136
152	1	4	Cf Troland, L T, *The Principles of Psychophysiology,* 142-145.
		17	*Ibid,* 196.
		22	Cf Troland, L T, in *A Handbook of General Experimental Psychology,* 688 f
		28	Ishihara, S, *Tests for Color-Blindness,* Stoelting, 5th ed, described in Clark, J H, *A. J. Physiol Opt,* '24, 5 269-276
	2	6	Cf. Hippel, A v, *Graefes Arch. f Ophth,* '80, 26 176-186, reported by S. Hecht in *A Handbook of General Experimental Psychology,* 818.

153	1	9	Cf. Parsons, J. H., *An Introduction to the Study of Color Vision,* Cambridge Univ Press, 2nd ed, 197 ff.
	3	9	Young, T, *Course of Lectures on Natural Philosophy and the Mechanical Arts,* Johnson, London, 1807, i, 440, ii, 613-632
154	1	10	Cf. Hecht, S, *J. Opt Soc Amer,* '30, 20 231-270, also Hecht, S, *A Handbook of General Experimental Psychology,* 790 ff
155	1	6	Cf Troland, L T, *op cit.,* '34, 678 ff
	2	4	Cf. Hering, E., in Rand, B, *The Classical Psychologists,* Houghton, '12, 582-596
156	2	13	Ladd-Franklin, C., *Colour and Colour Theories,* Harcourt, '29.
	4	4	Hecht, S, *Proc. Nat. Acad Sci.,* '28, 14 237-240
157	3	8	Cf Dodge, R, *A. J. Physiol.,* '03, 8 307-329; *J. Exp. P.,* '23, 6 169-181, *J Gen. P,* '30, 4 3-14
158	2	7	Cf. Miles, W R., and Bell, H. M, *J Exp P,* '29, 12 450-458
		10	Cf. Dearborn, W. F., *Arch. Philos. Psychol. Scient. Meth,* '06, no 4; also Dodge, R, *P. R. Monog.,* '07, 8, no 35
		11	Crosland, H R., *Univ. of Oregon Pub.,* '24, 2, no. 6, 1-168.
	3	5	Miles, W R, *J. Ed. P.,* '29, 20 520-529.
		12	Dodge, R., *P. R.,* '00, 7.454-465.
159	2	3	Cf Vernon, M. D., *The Experimental Study of Reading,* Cambridge Univ. Press, '31, 49 ff.
		7	Miles, W. R., and Bell, H M., *J. Exp. P.,* '29, 12·450-458.

Chapter X

163	2	9	Cf. MacLeod, R. B., *Arch P.,* '32, 21, no 135
		29	*Ibid*
165	2	6	Cf Henschen, S E, *Scand Sci. Rev,* 3 10 For discussion, see Klüver, H, *P. B,* '27, 24 320 ff
166	1	5	Cf. Fuchs, W, *Zsch. f. Psychol.,* '21, 86 1, *ibid,* '20, 84 67, reported in Kluver, H, *P B,* '27, 24 335
		11	Fuchs, W, *Zsch. F Psychol,* '21, 86 1, Kluver, H, *P B,* '27, 24 332 ff
		21	Gelb, A, and Goldstein, K, *Psych Forsch.,* '25, 6 187, cf Kluver, H, *P. B,* '27, 24 335 f.
168	1	15	Cf Helmholtz, H v, *Physiological Optics* (J P C Southall, ed) Optical Society of America, '25, iii, 306 ff, also Bourdon, *Rev. Philos.,* '00, 25 74. Both reported in Ladd, G T., and Woodworth, R S, *Elements of Physiological Psychology,* 428 ff
169	1	11	Cf. Troland, L. T., in *A Handbook of General Experimental Psychology,* 695.
171	3	4	Malinowski, B, *The Father in Primitive Psychology,* '27, 90
		10	*Ibid.*
172	1	10	Cf Peterson, J, *P. R,* '26, 33 218-236
	2	5	Cf Lotze, R H, in Rand, B, *The Classical Psychologists,* 545-556.
173	2	3	Cf Stratton, G M, *P R,* '97, 4 341-360, 463-481, *ibid.,* '96, 3 611-617, also Ewert, P. H, *G. P M,* '30, 7 177-363.
		11	Cf Stratton, G M, *P. R.,* '97, 4 469.
174	2	5	Thorndike, E. L, *P. R.,* '99, 6 282-291.
	4	8	Jastrow, J, *Mind,* '86, 539-554
		13	De Gowin, E L, and Dimmick, F. L., *J. Gen. P.,* '28, 1 114-122.
175	2	5	Dodge, R, *J. Exp P,* '23, 6 107-137.

176 1 22 Bourdon, R., *La Perception visuelle de l'espace,* '02.
23 *Ibid.*
179 1 2 Volkelt, H , *Ber. u. d. 9 Kong. f. Exper. Psychol.,* '26, 80-135.
183 2 3 Woodworth, R S , *Psychology,* Holt, 2nd ed , 315 f.
3 5 For drawing, cf. Arlitt, A. H., *Psychology of Infancy and Early Childhood,* McGraw-Hill, 2nd ed , 293 ff.; Lukens, H. T , *Ped Sem.,* '96, 4 79-110 For modeling, cf Johnson, B. J , *Child Psychology,* Thomas, '32, 323. For block building, cf. *ibid.,* 316 ff.
184 1 10 Cf. Boas, F , *The Mind of Primitive Man,* Macmillan, '19, 145 ff.
2 1 Lehmann, A , *Lehrbuch der ps Methodik,* '06.
4 *Ibid.*
185 1 6 Piaget, J., *The Language and Thought of the Child,* Harcourt, '26.
9 Cf. Terman, L M., *The Measurement of Intelligence,* Houghton, '16, 167 f.
186 1 4 Cf. Ladd, G T , and Woodworth, R. S , *Elements of Physiological Psychology,* 448 f.
10 Cf. *ibid.,* 437, 447 f.
188 1 8 *Ibid* , 441
190 2 12 Cf. Swift, E J , and McGeoch, J A., *J. Exp. P.,* '25, 8 240-249.
18 Gulliksen, H., *J. Exp. P.,* '27, 10 52-59.
191 1 8 Cf Hooper, S. E , *Proc. Soc. Psych. Res.,* '23, 33:621-664.
2 3 Hoagland, H , *J. Gen. P.,* '33, 9 267-287.
6 Cf. Hoagland, H., *J. Gen. P.,* '33, 9 267-287, also François, M., *C. R. Soc. biol.,* '28, 108 201-203.
192 1 15 Israeli, N., *Arch. P.,* '30, 18, no. 113
2 5 Meunier, R , *Le Hachich,* Bloud, Paris, '09.
3 3 Cf. Washburn, J. N , *J. Juv Res.,* '29, 13 1-18.

CHAPTER XI

195, note 1 Cf. Forbes, A., in *A Handbook of General Experimental Psychology,* chap. iii, 163 ff.
200 1 6 Cf Travis, L E , and Herren, R. Y., *A. J. Physiol.,* '30, 93 693 ff., *J. C. P.,* '31, 12.23-40.
201 2 10 Lashley, K S., *Arch. Neurol. and Psychiat.,* '24, 12 249-276, Franz, S. I , *Arch. P.,* '07, 1, no. 2.
202 2 6 Cf Rothmann, M , *Arch. f. Physiol.,* '08, 10.103 ff., reported by Johnson, H. M., *Beh Monog.,* '13, 2, no 8.
7 Saenger, A , *Neur. Centbl.,* '19, 38.10, reported in Kluver, H., *P. P.,* '27, 24 318 f.
14 Cf. Lashley, K S., *Brain Mechanisms and Intelligence,* Univ of Chicago Press, '29, 53, 59; cf also Lashley, K. S., *A. J. Physiol.,* '22, 59.44-71.
18 Kluver, H , *op. cit.*
3 5 Cf. Grunbaum, A., and Sherrington, C. S , *Proc. Roy. Soc* , London, '01, 69 206, '03, 72 152, reported in Ladd, G T., and Woodworth, R. S , *Elements of Physiological Psychology,* 236 ff.; cf. also Franz, S. I., *P. R. Monog.,* '15, 19, no 81.
203 1 5 Franz, S I. *P. R. Monog.,* '15, 19, no. 81.
2 15 Cf. Head, H , *Aphasia and Kindred Disorders of Speech,* Cambridge Univ. Press, '26, 316.
18 Cf Hinshelwood, J , *Congenital Word Blindness,* Lewis, London, '17, 45 f.

204	2	12	Franz, S I., *J. Gen. P.*, '30, 3:401-411.
	3	6	*Ibid*, 405 ff.
206	1	6	Cf. Troland, L. T., *The Principles of Psychophysiology*, Van Nostrand, '29, 1, 177 ff.

CHAPTER XII

208	2	3	Cf Koffka, K, *P. B*, '22, 19 531-585
209	2	1	Cf Titchener, E B., *Lectures on the Elementary Psychology of Feeling and Attention*, Macmillan, '08, 227 ff.
211	2	2	Cf Dallenbach, J M., *A. J. P.*, '29, 41 207-236
		8	Hamilton, W., *Lectures on Metaphysics and Logic*, 5th ed, no. 1, Lect. 16, 254.
		28	Cf. Dearborn, W. F, in *Arch. P.*, '14, 9, no. 30, 34-45.
212	1	10	Cf Terman, L. M., *The Measurement of Intelligence*, Houghton, '16, 56 ff.
		27	Cf Dearborn, W F, in *Arch P.*, '14, 9, no 30, 34-45.
	2	7	Cf Garrett, H E, *J. Ed P.*, '28, 19 601-613.
213	3	4	Cf Guilford, J P, *A J P.*, '27, 28 534-583.
216	1	4	Dallenbach, K M, *P B.*, '28, 25 499.
218	2	6	Weber, H E, *Annotationes anatomicae et physiologicae: programmata collecta*, Leipzig, '51, reported in Titchener, E. B, *Experimental Psychology*, Instructor's Manual, Quantitative, xiii ff.
219	2	5	*Ibid.*, xiv f
	3	4	*Ibid*, xx ff
		7	Cf. Konig, A, and Brodhun, E, *Sitzber. d. Akad. d Wiss*, Berlin, '89, 641; also Hecht, S, *J Gen. Physiol*, '24-'25, 7 235-269, reported by Hecht, S., in *A Handbook of General Experimental Psychology*, chap xiv, 759 ff
		16	Cf Fletcher, H, *J. Franklin Instit*, '23, 196 289-326, reported by Banister, H., in *A Handbook of General Experimental Psychology*, chap xvi, 889 ff
220	2	2	Cf Kellogg, W N., *Arch P*, '29, 17, no 106
		24	Cf Kellogg, W. N, *op cit*, Bressler, J, *Arch P.*, '33, '23, no 152, also Thorne, F C, *Arch. P*, '34, 25, no. 170
221	3	5	Cf Ladd, G. T, and Woodworth, R S, *Elements of Physiological Psychology*, 326
222	2	4	Wolf, E., *J. Gen. Physiol.*, '32-'33, 16 407-422, 773-786, reported by Hecht, S., in *A Handbook of General Experimental Psychology*, chap xiv, 762 f.
		5	Pavlov, I P, *Conditioned Reflexes* (trans by G V Anrep), Oxford Univ Press, '27, 124 ff, cf. also Yerkes, R. M., and Morgulis, S, *P. B*, '09, 6 257-273.
223	2	5	Cf. Hollingworth, H. L, in *Arch P.*, '14, 4, no 30, 75-91
		14	Gordon, K, *J. Exp P*, '24, 7 398-400
		17	Cf Thorndike, E. L, *T C Rec.*, '10, 2, no 2, for Handwriting Scale; Cattell, J McK, and Brimhall, D R (eds.), *American Men of Science*, The Science Press, 3rd ed, v f, for eminence of scientific men.

CHAPTER XIII

230	1	7	Cf Husband, R. W., *J C. P.*, '29, 9 361-377
234	2	2	Anderson, J E, *J. C. P.*, '26, 6.337-359

235 2 3 Kuo, Z Y, *J. C P,* '22, 2 1-27

236 2 11 Cf Dashiell, J F, *C. P M,* '30, 7, no. 32, Jackson, T. A., *G. P. M,* '32, 11, no 1

17 Watson, J B, *P. R. Monog,* '07, 8, no 33.

23 Cf Shepard, J F, reported in *Science,* '29, 69 xiv.

238 3 5 Bryan, W L., and Harter, N, *P. R.,* '97, 4 27-53, *ibid,* '99, 6 345-357

4 4 Cf. Book, W. F, *The Psychology of Skill,* Gregg, '25.

239 2 6 Cf Lashley, K S, *The Acquisition of Skill in Archery,* Carnegie Institute, '15

240 2 6 Cf Bryan, W. L, and Harter, N, *P. R.,* '99, 356 "The curves of Fig. XI show . that for many months the chief gain is in the letter and word habits"

13 Cf Book, W F., *The Psychology of Skill,* chap viii.

15 Cf. Trow, W. C, and Sears, R, *J. Ed P.,* '27, 18 43-47.

241 1 6 Cf Bryan, W L, and Harter, N, *P. R.,* '99, 6 351.

3 4 Cf. Peterson, G M., *J. Exp. P,* '28, 11 40-44

243 1 4 Sherrington, C. S., *The Integrative Action of the Nervous System,* '06, 55, 115 ff.

6 *Ibid.,* 36 ff.

18 *Ibid.,* 36-37.

22 Cf. Forbes, A., Davis, H., and Lambert, E., *A. J. Physiol,* '30, 95 142-173, reported by Forbes, A, in *A Handbook of General Experimental Psychology,* chap iii, 184 f.

2 9 Hudgins, C. V., *J Gen. P,* '33, 8 3-51.

244 1 1 Cf Pavlov, I P, *Lectures on Conditioned Reflexes,* International, New York, '28, chap iv, cf also Pavlov, I P, *Conditioned Reflexes,* 22

2 2 Cf Jones, H E., *J Genet. P,* '30, 37 485-498

3 12 Cf Pavlov, I P, *op cit,* '33, 233 n, *op cit,* '27, 41 f.

245 1 18 Erofeeva, M, *Electrical Stimulation of the Skin of the Dog as a Conditioned Salivary Stimulus,* Thesis, St Petersburg, '12

2 5 Jones, M C., *Ped. Sem,* '24, 31 308-316

246 2 2 Cf Pavlov, I. P., *op. cit,* '27, 48 ff For experimental analysis of inhibition, cf Hilgard, E R, *J. Gen. P,* '33, 8 85-113

247 1 11 Cf. Reynolds, M M., *T C Contrib. to Ed,* '28, no. 288

3 12 Cf Baldwin, J M, *Mental Development in the Child and the Race,* Macmillan, '00, 133, also Allport, F. H, *Social Psychology,* 39

248 1 1 Guernsey, M, *Zsch. f Psych.,* '28, 107 105-178.

2 2 Cf Hunter, W. S, *Behav. Monog,* '13, 2, no. 6

249 1 7 *Ibid.*

11 *Ibid.*

20 *Ibid.* Cf also Tolman, E. C., *Purposive Behavior in Animals and Men,* Appleton-Century, '32, 154 ff

23 Allen, C N, *Arch P.,* '31, 19, no. 127.

26 Cf Tinklepaugh, O L, *J. C P.,* '28, 8 197-236; also Yerkes, R. M. and D. N, *J. C. P.,* '28, 8 237-272

251 2 4 Cf Smith, S, and Guthrie, E. W., *General Psychology in Terms of Behavior,* '21, 100 ff.

253	1	3	Borovski, W. M., *Zsch. f. vergl Physiol.*, '27, 6 489-529.
	2	19	Lashley, K. S., and McCarthy, D. A., *J. C. P.*, '26, 6 423-434
254	1	3	Cf. Hamilton, G. V., *J. An. Behav.*, '11, 1 33-66.
255	2	2	Cf. Tolman, E C., *op. cit*, 29 ff, 151 ff
256	2	3	Kohler, W, *The Mentality of Apes,* Harcourt, '25.
		8	*Ibid.,* 107 f.
257	1	1	*Ibid.,* 110.
		5	*Ibid.,* 132 f.
	2	2	Cf. Carr, H, *P. R.*, '27, 34 87-106.
261	1	7	Cf. Koffka, K, *The Growth of Mind* (trans. by R. M. Ogden), Harcourt, '25, 102 ff.
263	2	3	Cleveland, A. A., *A. J. P.*, '07, 18 269-308.
	3	5	Cf. Lorimer, F, *The Growth of Reason,* Harcourt, '29, chap ii; also Markey, J. F, *The Symbolic Process and its Integration in Children,* chap. ix.
	4	12	Cf. Nice, M. M., *Ped. Sem.*, '17, 24 204-224, also Smith, M E., *Univ. of Iowa Studies in Child Welfare,* '26, 3, no 5 For summary, cf. Markey, J. F., *The Symbolic Process,* chap. iv.
264	2	4	Cf. Piaget, J, *The Language and Thought of the Child,* 11 ff

CHAPTER XIV

267	1	2	Cf Ladd, G. T, and Woodworth, R. S, *Elements of Physiological Psychology,* '11, 166 f.
268	2	5	Troland, L T., *The Principles of Psychophysiology,* ii, 90 ff, 95 ff.
		9	Cf. Shuey, A. M., *A. J. P.*, '24, 35·557-582, *ibid.,* '26, 37 528-537. Cf. also Berry, W., *A. J. P.*, '27, 38 584-596
269	3	5	Perky, C. W., *A. J. P.*, '10, 21 422-452.
270	2	8	*Macbeth,* II, i.
	4	4	Cf. Weinberg, M., and Allen, F, *Phil. Mag*, '24, 47·50-62, reported by Banister, H, in *A Handbook of General Experimental Psychology,* chap. xvi, 919
		5	Cf. Bishop, H G, *A J P*, '21, 32 305-325
271	2	3	Cf. Galton, F., *Inquiries into Human Faculty and its Development,* Macmillan (London), sect on Mental Imagery, see also Appendix f.
		10	*Ibid.*
		19	*Ibid.*
273	2	3	Fernald, M. R, *P. R. Monog.*, '12-'14, 1-169.
274	1		Cf Kluver, H., in Murchison, C (ed), *A Handbook of Child Psychology,* Clark Univ. Press, 2nd ed, chap. xvii, also Kluver, H, *G. P. M.*, '26, 1, no. 2.
	2		Cf. Banerji, M. N, *Indian J. P.*, '30, 5 147-159.
		11	Taylor, Cornelia D, *J. Gen. P.*, '30, 4 229-246.
276	3	3	Calkins, M. W., *P. R. Monog.*, '96, 1, no 2.
278	1	3	Galton, F., *op. cit.,* sect. on Psychometric Experiments.
	2	3	Cf. Wreschner, A., *Zsch. f Psychol.*, '07, Erg Bd. 3, 1 Teil.
280	2	5	Cf Wells, F. L, *P. R*, '11, 18 229-233
		7	Cf. Jung, C. J., *Studies in Word Association* (trans. by M. D Eder), Moffat, Yard, '19.
		12	Cf. *ibid*
	3	3	Kent, G. H., and Rosanoff, A. J., *A. J. Ins.*, '10, 67·317-390
282	1	11	Cf. Hauck, E., *Zur differentiellen Psychologie des Industrie- und*

			Land Kindes, Beltz, '29, reported by K. Lewin in *A Handbook of Child Psychology*, chap. iv, 108 ff
		19	Cf. Thorndike, E. L, *Educational Psychology, III Mental Work and Fatigue and Individual Differences*, Teachers College, '14, 69 ff.
283	1	10	Cf Duffy, E., *G. P. M*, '30, 7 1-79; *A. J. P.*, '32, 44 535-546. See also Freeman, G. L, *A. J. P*, '33, 45 17-52, Bills, A. G., *A. J. P*, '25, 36 102-112.
284	2	12	Cf Cattell, J. McK, *Philos. Stud.*, '88, IV, 241 ff , *Mind*, XII, 68 ff

Chapter XV

286	2	3	Cf Rosanoff, A. J., *Manual of Psychiatry*, Wiley, 5th ed, 42 ff, *passim*.
288	2	4	Cf Titchener, E. B, *A Beginner's Psychology*, Macmillan, '15, 178 ff.
290	3	20	Ebbinghaus, H., *Grundzuge der Psychologie*, Verlag von Veit, '05, 1, 681 f.
291	3	9	Woodworth, R. S., *P. R.*, '15, 22 18 f.
292	2	7	Kulpe, O, *Ber. u. d. 1 Kong. f. exp. Psych.*, '04, 56
293	2	15	Gates, A. I., *Arch. P.*, '17, 6, no. 40
294	2	7	Cf Perkins, N. L, *Brit. J. P.*, '14-'15, 7 253-261.
		14	Piéron, H, *L'Année Psychol*, '13, 19.91-193.
295	3	2	Cf. Geyer, M. T., *J. Exp. P.*, '30, 13.290-292.
296	3		Cf. Ebbinghaus, H, *Memory* (trans. by H. Ruger and C E Bussenius), Teachers College, '13, chap. ix.
297	2	3	Cason, H, *J. Exp. P.*, '26, 9 195-227.
		7	*Ibid*, 299-324
299	2	5	Cf. Poppelreuter, W., *Monatssch f. Psychol. u. Psychiat. u. Neurol.*, '15, 37 278-323, also Reed, H B, *P. R*, '18, 25 128-155
		10	Cf Warden, C J, *J. Exp. P*, '24, 7 243-275
301	1	5	Cf Greene, E B, *J. Ed Res.*, '31, 24 262-273
	2	13	Van Ormer, E B., *Arch. P*, '32, 21, no. 137
302	2	9	Cf. Myers, G. C., *Arch P.*, '13, 4, no. 26; see also Shellow, S. M., *Arch P.*, '23, 10, no. 64
303	2	10	Cf. Judd, C. H., and Cowling, D J, *P. R. Monog.*, '07, 8 34.
	3	3	Cf. Gennep, A van, *La formation des Légendes*, Flammarion, '10.
304	1	2	Cf. Bronner, A, in *Proc. 9th Int'l Cong. P*, Psychol. Rev. Co., '30, 97 f.
		7	*Ibid.*
	2	9	Stern, W, *Beitrage zur Psychologie der Aussage*, Barth, '03-'04, i.
305	2	4	Cf Thorndike, E L, *Educational Psychology, II, The Psychology of Learning*, Teachers College, '13, 360 ff
306	2	4	James, W, *Principles of Psychology*, Holt, '90, chap xvi, 667 n.
		9	Thorndike, E L, and Woodworth, R S, *P. R.*, '01, 8 247-261,384-395, 553-565
307	2	6	Lashley, K S., in C. Murchison, *Foundations of Experimental Psychology*, '29, 547.
	3	9	Jackson, T. A., *G. P. M*, '32, 11 1-59.
308	2	10	Cf Robinson, E S, *P. R. Monog.*, '20, 28, no. 128, also Harden, L. M, *J Gen P*, '29, 2 421-432.
311	4	12	Smith, W. W., *Brit. J. P.*, '21, 11 236-250.
312	1	5	Cf. Jones, H. E., *J. Gen. P.*, '29, 2 263-272; Wechsler, D., *Arch. P.*, '25, 12, no 76.

Chapter XVI

315	3	4	Marbe, K, *Experimentell-psychologische Untersuchungen uber das Urteil,* Engelmann, '01, 16, reported in Titchener, E B, *Lectures on the Experimental Psychology of the Thought Processes,* Macmillan, '09, 81.
316	1	5	Watt, H J, *Arch f d. ges. P.,* '05, 4 289-436, reported in Titchener, E B, *op cit.,* 85 ff
317	4	6	Ruger, H A, *Arch P.,* '10, 2, no 15
320	1	3	Dunkelberger, G. E, and Rumberger, E. K, *J. Gen P.,* '30, 4 383-389.
		7	Maier, N R F, *J. C. P,* '30, 10 115-144
	2	5	Maier, N R F, *J. C. P.,* '31, 12 181-194
321	1	6	Ruger, H. A., *Arch. P,* '10, 6, 21 f
322	3	2	Alpert, A, *T. C. Contrib. Educ.,* '28, no 323.
324	3	4	Dunkelberger, G E., *op. cit*
325	2	4	Cf. Romanes, G. J., *Mental Evolution and Man,* Kegan, Paul, Trench, '89, 68-80 Discussed by W. James, in *The Principles of Psychology.* Holt, '90, ii, 327 ff.
327	3	3	Heidbreder, E, *Arch P,* '24, 11, no 73
329	2		Cf Ogden, C K, and Richards, I A, *The Meaning of Meaning,* Kegan Paul, '23
330	3		Cf Piaget, J, *The Language and Thought of the Child,* Harcourt, '26, *Judgment and Reasoning in the Child,* '28, *The Child's Conception of the World,* '28, *The Child's Conception of Physical Causality,* '30.
331	1	4	Boeck, W, *Das Mitleid bei Kindern,* v Munchow, '09.
	2	12	Piaget, J, *The Child's Conception of the World.*
	3	3	*Ibid,* 91 f.
332	1	2	Piaget, J, *Judgment and Reasoning in the Child*
		25	Abel, T M, *A. J P,* '32, 44 123-132
333	1	7	Kuo, Z Y, *J. Exp P,* '23, 6 247-293
		8	Jones, E, *J Abn. P,* '08,
334	3		Watson, J B, *Behaviorism,* Norton, '25, 173 ff, rev ed, '30, chaps. x, xi
335	2	1	Cf Wyczoikowska, A, *P R,* '13, 20 448-458, Reed, H B, *J. Exp. P.,* '16, 1 365-392.
		12	Thorsen, A. M, *J. Exp P.,* '25, 8 1-32
336	2	3	Rizzolo, A, *The Effect of Vocal Distraction upon Mental Work,* Columbia Ph D. dissertation, '31.
337	2	3	Aristotle, *Organon.*
		8	Bacon, F, *Novum Organum.*
	3	5	Mill, J S, *Logic,* 1843

Chapter XVII

343	1	13	Stewart, J R, *Sci Mon,* January, '30, 71-78.
344	2	2	Cf Kline, L W. and F L, *Psychology by Experiment,* Ginn, '27, 262 ff
345	2	5	Beck, S J, *Arch P,* '32, 21, no 136
	3	6	Feingold, G A, *A J. P.,* '15, 26 540-549

346	2		Cf Bleuler, P E , *Textbook of Psychtatty* (Eng ed , A A Bnll, ed), Macmıllan, '24
347	3	6	Cf Horton, L H , *Dıssettatıon on the Dteam Problem,* Cartesıan Res Soc., Phıla , '25.
		8	Kleın, D B , *Unıv Texas Bull.,* '30, no 3009
349	2	6	James, W , *The Prıncıples of Psychology,* Macmıllan, '90
350	2	4	Freud, S , *General Intıoductıon to Psychoanalysıs* (tıans by G S Hall), '20, 102
		16	Cf Kımmıns, C W , *Chıldten's Dteams,* Longmans (London), '20
351	3	11	Cf Bınet, A , *The Alteıatıons of Peısonalıty* (trans. by H G. Baldwın), Appleton-Century, '96, also Janet, P , *L'Automatısme Psychologıque,* Alcan, '89.
352	1	22	Cf Muhl, A. M., *J. Abn. & Soc. P.,* '22, 17 166 f , *ıbıd*, '23, 18 1 f.
		23	Cf Coıiat, I H., *Abnormal Psychology,* Dodd, Mead, '10, 36 ff
		28	Cf Parısh, W., *Hallucınatıons and Illusıons,* Scott, '98, 70 f , also Sıdıs, B., and Goodhart, S P, *Multıple Peısonalıty,* Appleton-Century, '19, 257 ff
353	2	19	Pıınce, M , *The Unconscıous,* Macmıllan, 2nd ed , '21, 53 f , 58 f
357	2		For refeıences to the materıal of thıs paragraph, cf Hutchınson, E. D , *P. B.,* '31, 28 392-410.
358	3	17	Rossman, J , *The Psychology of the Inventor,* Inventors Pub , Washıngton, '31
359	3	8	Lowes, J L , *The Road to Xanadu,* Houghton, '30.

Chapter XVIII

364	1	12	Galton, F , *Heıedıtary Genıus,* Macmıllan (London), '69, *Inquırıes ınto Human Faculty and ıts Development,* Macmıllan (London), '83.
365	1	1	Bınet, A , and Sımon, T , *L'Année Psychol*, '05, 11 245-336
		9	Bınet, A , *L'Année Psychol.,* '11, 17 145-201.
		10	Terman, L M , *The Measurement of Intellıgence,* Houghton, '16
371	1		Freeman, F. N , *Mental Tests,* Houghton, '26, 15 ff
372	2	16	Cf. Trabue, M R., and Stockbrıdge, F. P., *Measure Your Mınd,* Doubleday, '22, also Trabue, M. R., *T. C Contııb. to Educ.,* '16, no 77, 77 f.
	3	5	Cf. Bronner, A F , Healy, W , Lowe, G M , and Shımbeıg, M. E , *A Manual of Indıvıdual Mental Tests and Testıng,* Lıttle, Brown, '27, chaps vı, vıı.
373	1	6	Knox, H A , *J. Amer. Med Assoc.,* '14, 62 741-747; descrıbed ın Pıntner, R , and Paterson, D. G., *A Scale of Perfoımance Tests,* Appleton-Century, '17, 58 ff
		12	Pıntner, R , and Paterson, D G , *op. cıt*, 53 ff
	2	3	Healy, W , *P R*, '14, 21 189-203, cf. also Pıntner, R , and Andeıson M. M., *The Pıcture Completıon Test,* Warwıck, '17
374	3	3	Knox, H A , *op. cıt.*, reported ın Pıntner, R., and Paterson, D G , *A Scale of Perfoımance Tests,* 67 ff. See also Pıntner, R , *P. R*, '15 22 377-401
375	2	10	Johnson, B J , *Mental Growth of Chıldren,* Dutton, '25, chap ıv ff , cf. also Johnson, B J , and Schrıefer, L , *J. Ed P.,* '22, 13 408-417
	3	6	Cf. Stenquıst, J L , *Col. Con Ed*, '23, no 130.
376	2	3	Cf Yoakum, C S , and Yerkes, R M , *Army Mental Tests,* Holt, '20
378	2	16	Thorndıke, E L , *J. Ed. P.,* '23, 14 513-516, Thorndıke, E L , Breg-

			man, E. O, Tilton, J. W, and Woodyard, E., *Adult Learning,* Macmillan, '28
379	1	7	Jones, H E, and Conrad, H S, *G P. M.*, '33, 13, no. 3.
		8	Cf. Thorndike, E. L, *et al., op cit*, Appendix V.
	2	7	Cf. Greene, E. B., *P B.*, '33, 30 578.
		9	Miles, W. R, *Proc. Nat. Acad Sci.*, '31, 17 627-633.
380	2	12	Gesell, A., *The Mental Growth of the Pre-School Child,* Macmillan, '25.
		21	Bayley, N., *G. P. M.*, '33, 14 1-92.
381	2	2	Cf. Goodenough, F. L., *P. R.*, '27, 34 440-462
	3	19	*Ibid.*
382	4	3	Cf. Woodrow, H., *Brightness and Dullness in Children,* Lippincott, 2nd ed, chap viii ff. For other definitions of intelligence, see *J. Ed P.*, '21, 12 123-147, 195-216 Two are given below· Thorndike, E. L —"The power of good responses from the point of view of truth or fact." Terman, L M.—"An individual is intelligent in proportion as he is able to carry on abstract thinking" Other definitions Binet, A.—"L'intelligence se marque par la meilleure adaptation possible de l'individu à son milieu" (*L'Année Psychol.*, '11, 17 172), Stern, W.—"Intelligence is a general capacity of an individual consciously to adjust his thinking to new requirements, it is general mental adaptability to new problems and conditions of life" (*The Psychological Methods of Testing Intelligence,* trans. by G. M. Whipple, Warwick, '14)
384	2	9	Spearman, C, *A. J P.*, '04, 15 201-293
385	2	11	Spearman, C, *The Abilities of Man,* Macmillan, '27, chap xii.
	3	11	Cf. Kelley, T. L., *Crossroads in the Mind of Man,* Stanford Univ. Press, '28.
386	2	5	Levy, D. M., *Arch. Neur. and Psychiat.*, '24, 11 669-673.

CHAPTER XIX

389	1	18	Reported in Gakko Eisei, 3, 2. Abstracted in *P Ab*, '27, 1, no. 677
391	3	3	Cf. Newman, H H, *The Biology of Twins,* Univ. of Chicago Press, '17, 10, Klein, P, *Arch. f. Gynakol*, '27, 130 788-812 (reported by A. Gesell in *A Handbook of Child Psychology*) reports 33% identical twins in total twin population of 112
		19	Gesell, A., and Thompson, H, *G P. M.*, '29, 6, no 1, 14, 15 ff.
392	1	4	Strayer, L C, *G. P. M.*, '30, 8 209-319.
399	3	3	Cf. Bruner, F. G., *Arch. P*, '08, 2 11, also Woodworth, R. S, *Science,* n s., '10, 31 171-186, Rivers, W. R. H., *Brit. J P*, '05, 1 321-396.
		8	Cf. Myers, C. S, *Cambridge Anthropological Expedition to the Torres Straits,* '03, ii.
400	1	6	Arlitt, A H, and Buckner, S H, *P B*, '27, 24·190-191.
	2	8	Cf. Benedict, R, *Patterns of Culture,* Houghton, '34.
		11	Cf Boas, F., *Smithsonian Inst. Rep of Bur. of Ethnol.*, '88, 6 409-669.
		12	Jones, T. E, *Mountain Folk of Japan,* Doctoral dissertation in the Library of Columbia Univ, '26.
401	3		Cf. Garth, T. R, *Race Psychology,* McGraw-Hill, '31, 73 f., 233 ff.
403	1	1	Klineberg, O., *Negro Intelligence and Selective Migration,* Columbia Univ. Press, '35.

	3	6	Peterson, J, and Lanier, L. H, *Ment. Meas. Monog.*, '29, no 5.
	4	3	Klineberg, O, *Arch. P*, '31, 20, no 132.
406	2	7	Cf. Freeman, F N., *et al., 27th Yrbook, N. S. S. E.*, '28, part 1, 101 217, Burks, B. S, *ibid.*, chap x, 219-316.
407	2	15	Woolley, H T., *School and Soc.*, '25, 21 476-482.
	3	11	Terman, L. M., *Genetic Studies of Genius*, Stanford Univ. Press, '25, 1, 71
408	3	3	Gordon, H., Board of Educ (London), *Educ. Pamphlets*, '23, no. 44.
409	2	3	Sherman, M, and Henry, T. R., *Hollow Folk*, Crowell, '33.
	3	4	Yerkes, R. M., *Memoirs of the Nat. Acad. Sci*, '21, xv, 705 ff.
410	1	2	Cf Chapman, J C, and Sims, V. M, *J. Ed. P.*, '25, 16 380-390.
		9	McCormick, M. J., *Soc. Sci Monog.*, 1 3.
413	3	5	Cf. Goddard, H. H., *Feeble-mindedness*, Macmillan, '14, 505, 513.
	4	2	Cf. Doll, E A., Phelps, W. M, and Melcher, R. T., *Mental Deficiency Due to Birth Injuries*, Macmillan, '32.
417	2	20	Cf. Pintner, R., *P. R.*, '18, 25 286-296

Chapter XX

421	2	7	Cf. Hastings, G. B, *The Physiology of Fatigue*, U. S. Pub. Health Bull, '21, 17.
423	1	3	Cf. Thorndike, E L., *Educational Psychology*, Teachers Coll. Press, '14, iii, chaps. i-v; see also Goldstein, H, *Arch. P.*, '34, 25, no 164.
425	1	13	Cf. Thorndike, E. L, McCall, W. A, and Chapman, J. C, *Ventilation in Relation to Mental Work*, Teachers Coll. Press, '16, cf also Thorndike, E. L, and Kruse, P J, *School and Soc.*, '17, 5 657-660.
426	2	6	Knight F. B, and Remmers, H. H., *J Appl. P*, '23, 7 209-223
427	2	10	Kitson, H. D, *The Univ J of Business*, '22, 1 54-68.
428	1	3	Cf Vernon, H M, and Warner, C G, *Person J.*, '32, 11 141-149, also Harmon, F. L, *Arch. P*, '33, 23, no 147.
430	4	3	Cf. Shepard, J F., *The Circulation and Sleep*, Macmillan, '14.
432	2	2	Cf. Kohlschutter, E., *Zeit. f. rationelle Med.*, '62, 17 209-253, *ibid.*, '69, 34·42-48, reported in Johnson, H. M., and Swan, T. H., *P. B.*, '30, 27 1-39 The latter reference is an excellent summary of the whole study of sleep.
		7	Cf. Johnson, H. M., and Weigand, G. E, *Proc. Penna. Acad. Sci*, '27, 2 43-48
	3	13	Cf Johnson, H M, Swan, T H., and Weigand, G E., *J. Amer. Med Assoc*, '30, 94·2058-2062, also Valentine, W. L, *Readings in Experimental Psychology*, Harper, '31, 280-290.
	4	1	Hollingworth, H. L, *The Psychology of Thought*, Appleton-Century, '26, chap ii
434	5	5	Hollingworth, H. L, *Arch. P.*, '12, 3, no. 22.
437	2	11	Cf O'Shea, M. V., *Tobacco and Mental Efficiency*, Macmillan, '23.
	4	2	Cf. Miles, W. R, *Alcohol and Human Efficiency*, Carnegie Inst., Washington, '24 See also Dodge, R., and Benedict, F. G., *Psychological Effects of Alcohol*, Carnegie Inst, '15.
440	2	10	Slocombe, C. S, and Brakeman, E. E., *Brit. J. P.*, '30, 21.29-38.

Chapter XXI

444	2	5	Washburn, R. W., *G. P. M*, '29, 6·397-539
445	1	5	Shirley, M, *The First Two Years*, Univ of Minn. Press, '33, iii.
	2	9	Cf. Benedict, R, *Patterns of Culture*, Houghton, '34.

446	2		Cf Markey, J. F, *The Symbolic Process and its Integration in Children,* Harcourt, '28; see also Lorimer, F., *The Growth of Reason,* Harcourt, '29.
447	4	3	Cf. Baldwin, J M., *Mental Development in the Child and Race,* Macmillan, '95, see also Hall, G. S, *Adolescence,* Appleton-Century, '04
448	2	1	Cf Horowitz, E L, Spatial Localization of Self, *J. Soc. P.* (in press)
	3	2	*Ibid*
449	2		Cf Piaget, J, *Language and Thought of the Child* See also McCarthy, D. A, *The Language Development of the Pre-School Child,* Univ. of Minn Press, '30.
450	1	24	Boeck, W, *Das Mitleid bei Kindern,* v. Munchow, '09.
	2	2	Cf Buhler, C, *The First Year of Life,* '30.
451	1	13	Cf Humphrey, G., *J Abn. & Soc. P.,* '22, 17 113-119.
	2		Cf Piaget, J, *The Child's Conception of the World,* chap iv.
452	1	7	Greenberg, P J, *A J. P,* '32, 44 221-248.
	2	2	Cf Hurlock, E B, *J Ed. P,* '25, 16 145-159.
453	3	4	Cf. Marston, L R., *Univ of Iowa Stud. in Child Welfare,* '25, 3, no 3
454	1	20	Jack, L M, *Univ. of Iowa Stud. in Child Welfare,* '34, no 3
	2	13	Cf Goodenough, F L *J. Juv. Res,* '28, 12 230-235, also Olson, W C., *Problem Tendencies in Children,* Univ of Minn. Press, '30
456	1	8	Cf Parten, M B, *J Abn. & Soc. P,* '32, 27 243-269
	3	5	Hartshorne, H, and May, M A, *Studies in Deceit,* Macmillan, '28, *Studies in Service and Self-Control,* '29, *Studies in the Organization of Character,* '30
463	3		Cf Murphy, G, and Jensen, F, *Approaches to Personality,* Coward-McCann, '32, part iii by J Levy.
466	3	4	McDougall, W., *An Introduction to Social Psychology,* Luce, 14th ed, 199 ff.
469	2	6	Cf Johanson, A M, *Arch P,* '22, 8, no 54
	3	3	Freeman, G L, *J Gen P,* '30, 4 309-334.
470	1	6	Henmon, V A C, *Arch P.,* '06, no 8
	2	14	Hudgins, C. V, *J Gen P,* '33, 8 3-51

Chapter XXII

475	3	5	Downey, J. E, *P R,* '10, 17 205-216
476	1	8	Allport, G. W, and Vernon, P E, *Studies in Expressive Movement,* Macmillan, '33
478	3	2	Rice, S A., *Quantitative Methods in Politics,* '28, 56 ff
482	2	6	Chen, W K, *Arch P,* '33, 23, no 150
483	3	7	Cf Moore, H T, and Gilliland, A R, *J. Appl. P.,* '21, 5 97-118, also Gilliland, A R, *ibid,* '26, 10 143-150
		10	Cf. Henning, H, *Prakt Psych,* '23, 4 97-104
484	1	9	Cf Porter, E, *Student Opinion on War,* Ph D dissertation in Univ. of Chicago Library, '26
486	1	25	Thurstone, L L and T G, *J. Soc. P.,* '30, 1 3-30
488	3	4	Cf Jaensch, E R, *Eidetic Imagery and Typological Methods of Investigation,* '30 For the implications of these hypotheses, see Kluver H, *Amer. J. Psychiat,* '31, 10 441-458.

Chapter XXIII

493	2	2	Cf Watson, J B., *Psychology from the Standpoint of a Behaviorist,* Lippincott, 3rd ed , '29, *Behaviorism,* Norton, 2nd ed , '30
495	4	2	Janet, P , *The Major Symptoms of Hysteria,* Macmillan, 2nd ed., '13
498	3	1	Cf Wingfield, H E , *An Introduction to the Study of Hypnotism,* Baillière, Tindall and Cox, 2nd ed , '20, also Hull, C L., *Hypnosis and Suggestibility,* Appleton-Century, '33.
507	2	2	Jung, C G , *Psychology of the Unconscious* (trans. by B. M Hinkle), Moffat, 2nd ed., '21.
	4	3	Jung, C G , *Psychological Types* (trans by H. G Baynes), Kegan Paul, 2nd ed., '23
508	3		Cf. Adler, A., *Study of Organ Inferiority and its Psychical Compensations* (trans. by S. E Jelliffe), Nerv. and Ment Dis Pub Co , '17, *The Practice and Theory of Individual Psychology* (trans. by P. Radin), Kegan Paul, '24, *Understanding Human Nature* (trans. by W. B. Wolfe), Greenberg, '27
511	2	2	Cf Adler, A , *Problems of Neurosis,* Cosmopolitan, '30, 41, 75 ff.
514	2	12	Kretschmer, E , *Physique and Character* (trans by W J. H Spratt), Kegan Paul, '25.

Chapter XXIV

518	1		Cf Watson, J B , *op cit.,* Dashiell, J. F , *Fundamentals of Objective Psychology,* Houghton Mifflin, '28, Hunter, W S , *Human Behavior,* Univ. of Chicago Press, '28
520	2		Cf Titchener, E B , *Systematic Psychology · Prolegomena,* Macmillan, '29, *A Beginner's Psychology,* Macmillan, '15
523	1		Cf Kohler, W , *Gestalt Psychology,* Liveright, '29
525	2	6	Wertheimer, M , *Zsch f Psychol.,* '12, 61 161-265
526	3	1	Cf Kohler, W., *The Mentality of Apes* (trans by E Winter), Kegan Paul, '25, also Koffka, K., *The Growth of the Mind* (trans. by R. M. Ogden), Kegan Paul, '25.
527	2	6	Cf Petermann, B , *The Gestalt Theory and the Problem of Configuration,* Harcourt, '32.

GLOSSARY AND INDEX

trum. The most usual form of this is red-green blindness, in which condition red, or green, or both, appear as yellow: 152-153, 223, 389-390

Color constancy—*The phenomenon of the same experience of color arising from entirely different wave lengths and saturations, or, stated the other way about, the dependence of color experience upon the entire field of stimulation to which the individual is subjected:* 163-164

Color mixture, 146-147, 150-155, binocular, 156-157

Color wheel—*A rotating shaft, driven by a variable-speed motor, upon which may be mounted colored cardboard disks. The disks are slit along one radius so that they may be made to overlap one another. Rotation produces momentary, successive stimulation by the various wave lengths; sufficient speed will result in mixture of the colors. By varying the speed of rotation and the proportional area of the colors, the phenomena of color and of brightness vision may be investigated:* 149-150

Colors, complementary—*Colors which when mixed give gray:* 150

Compensation—*Increased development or functioning of one organ when impairment of another organ of similar function occurs. Adler uses the term, by analogy, to describe the process by which an individual seeks to balance a sense of inadequacy with a real or fancied superiority in some other aspect of his personality:* 407, 508-509

Competition, 407, 452

Complementary colors, 150

Completion test—*A test, often found in intelligence tests, in which the subject must fill in a blank with the missing word, number, etc.:* 372

Complex—*A system of affectively toned ideas:* 107

Complex indicators, 107

Compulsion—*An irresistible impulse to perform some apparently unreasonable act, frequently found in neurotic individuals:* 497

Concept—*A symbol which stands for a specific quality possessed in common by a number of stimuli:* 184-185, 324-334

Conditioned response—*A response elicited by a stimulus which is, ordinarily, biologically inadequate to arouse the response, but which, having been presented along with a biologically adequate stimulus, has come to be an effective substitute for the biologically adequate stimulus.* 242-255, 470-472, 493-495

Cones—*Cone-shaped receptor cells of the retina:* 146-147

Conflict—*The mutual interference of different drives. Psychoanalysis uses the term to describe those struggles between the individual's instincts which result in the repression of many desires, fears, and the like into the unconscious:* 500-506, 511-514

Conjuring, 270

Conscience—*The judgment of right and wrong. In Freudian terms, conscience is the operation of the super-ego, which comes from the child's tendency to identify itself with those who represent the force of discipline, especially the parents* 503

Consciousness—*Awareness; one's immediate experience, as contrasted with inferences regarding the experience of others:* 209-211

Consistency—*Similarity of response in analogous situations:* 458

Consummatory response—*The last response in a series, by which the organism achieves direct contact or interaction with the stimulus:* 63-64, 74

Contiguity, association by—*The formation of associative bonds between experiences which are parts of the same total situation:* 275

Contrast, association by—*The linking together of contrasting things:* 150

Control—*(1) The influences which determine the direction of an associative activity, (2) a subject whose*

part carries on an activity of which the rest is unaware, although later, under appropriate conditions, recall of the given activity may be effected. (Other senses of the term are in use, cf. p. 354, the above, however, is preferred.). 351-356

Distraction—*A stimulus whose presence interferes with the dominant activity of the moment. The term may also be used to denote the action of interference:* 427-428

Dominance, ocular—*Habitual use of one eye for sighting or fixating, the position of the other eye being controlled by the dominant eye.* 159; physiological—*Differential effectiveness in favor of one stimulus, one drive, or one neural pattern.* 245-246

Dreams—*Vivid imagination occurring during the sleeping state The form and sequence of the imagery characteristically display lack of critical control such as is imposed by the individual's contact with the world when awake* 4 8, 331, 347-351, 359, 432

Drive—*Basic tendency to activity The action tendency, initiated by shifts in physiological balance ("restlessness"), is accompanied by sensitivity to particular types of stimuli so that eventually a consummatory response occurs which brings cessation of the drive.* 15-17, 27, 52-70, 227, 232, 314, 346-347, 356-357, 426-427, 485-486 *See also* Interest, Maternal behavior, Sex behavior

Effector—*Response cell, either muscle or gland.* 45-46

Efferent fibres—*Fibres which carry impulses from the central nervous system to effectors* 44-46

Ego—*The set of symbols which differentiates the experiencing organism from the outside world (Freud holds that this is only one part of the ego since part of the socially acceptable self is unconsciously concerned with repression of the id):* 500-501

Egocentrism—*Piaget uses the term to mean the individual's (especially the child's) absorption in his own mental habits, which reflects his inability to see things from a social point of view* 332, 449-450

Eidetic image—*The experience, especially prevalent among children, of continuing for minutes or even hours to see objects which have been previously looked at* 274

Eidetic type—*Personality type prone to eidetic imagery:* 488-490

Electro-cardiograph—*Instrument which makes electrical recording of rate and force of the heart beat:* 103

Embryo—*An organism in the very early stages Frequently synonymous with fœtus, although the latter term is often restricted to the human organism older than the fifth prenatal week:* 36-40

Emergence, theory of—*Belief, held by some biologists, that an organism cannot be understood wholly in terms of physics and chemistry or in terms of the properties of the structures from which it has evolved, but must be studied as a unique, dynamic pattern, having attributes not present previously in the world.* 524

Emotion—*Excited or aroused condition, with responses characteristically involving innervation of the autonomic nervous system:* 20, 24, 60, 64, 71-112, 204, 287, 315, 351-352, 360-362, 493-494, expression of, 84-96, measurement of, 103-112, theory of, 77-84 *See also* Affect, Feeling, Personality

Emotional pattern—*Behavior pattern characteristic of a specific emotional response.* 84-96

dark on the other. An observer on the dark side can see the subject on the lighted side, while remaining invisible to the subject. 318, 454, 455

Opposite test—*A test in which the subject is instructed to find the opposite of each of a number of words:* 283

Optic nerve—*Cranial nerve leading from the retina to the brain:* 145

Organic sensation—*Experience of the stimulation of sensory organs in the viscera or of the movements of the viscera (which may or may not involve tactile sensation):* 125

Organism—*The whole living being:* 3-4, 10, 11

Organization—*The way in which separate parts are unified in their functioning* 205-207, 216, 446-449

Overlapping—*Perceptual response to one item during motor response to the immediately preceding item·* 283-284

Over-learning—*Learning carried beyond the point of one perfect repetition.* 300

Overtones—*Tones resulting from vibrations of parts of a resounding body, occurring simultaneously with the vibrations of the whole body, and having a higher pitch (because of a more rapid vibration rate) than the pitch of the tone which results from vibration of the whole body* 136-139

Overwork, 429-430

Pain—*Experience resulting from the stimulation of the pain spots.* 71-77, 88, 196-197

Paired associates, method of—*Presentation of stimuli in pairs with directions to the subject to learn the pairs in such a way that he will be able to recall one when the other is presented alone Subsequently one member of each pair is presented and the subject's learning measured in terms of the number of correct responses made or the number of presentations of the pairs necessary to achieve an arbitrary standard of perfection:* 288-290

Paradoxical cold—*The derivation of experience of cold from warm stimuli.* 123

Paramnesia—*The feeling of familiarity with objects or situations viewed for the first time.* 287-288

Parathyroid glands—*Endocrine glands, lying near the thyroid glands, which play an important part in the body's use of calcium and seem to play a part in maintaining emotional stability·* 61

Pathetic fallacy—*Attribution of personal feelings to inanimate objects·* 97

Patterns, of emotion—*Modes of organization of response during emotional expression.* 84-96, perceptual—*Modes of organization of sense experience during perception:* 183

Pavlov, I P, 222, 244

Paynter, R H, 439

Pedigree method—*Study of the resemblances between members of successive generations* 412

Perception—*Interpretation of a stimulus:* 3-4, 79, 125, 162-207, 217-218, 255-263, 324, 359, 372-373, space, 164-175, time, 190-193 Percept—*An experience which comes as a result of the process of perception.*

Performance tests—*Tests, usually intended to give a measure of intelligence, in which an individual's ability to perceive and manipulate objects is measured.* 372-376

Perimeter—*Apparatus for testing the sensitivity of the periphery of the retina While the subject maintains forward fixation, an object is moved along a wide arc and stimulates peripheral points of the retina at different distances from the fovea. The subject's report of the qualities of the seen object gives a measure of the sensitivity of the retinal area stimulated:* 148

Persistence—*Capacity to continue work despite annoyance* 459

Personality—*(1) All of those qualities, modes of reaction, etc., which set off an individual as distinct from all others. (2) The integration of these*